
Virtual Information Piles for Small Screen Devices

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Abstract

We describe an implementation that has users 'flick' notes, images, audio, and video files onto virtual piles beyond the display of small-screen devices. This scheme allows PDA users to keep information close at hand without sacrificing valuable screen real estate. Our approach takes advantage of human spatial memory capabilities. It also obviates the need to browse complex folder trees during a working session. The system also allows co-located individuals with PDAs to share and organize information items (e.g., photos, text, sound clips, etc.) by placing them in shared, imaginary off-screen piles. We also introduce an extension that allows PDA owners to transfer information piles to and from a shared tabletop display.

Keywords

Mobile computing, PDA, piles, information management, information sharing, screen real-estate.

ACM Classification Keywords

H5.2 [Information interfaces and presentation]: User Interfaces. - Graphical user interfaces.

Introduction

The screen size limitation of palm sized mobile devices is the one constraint that receives no relief from Moore's law. While we can count on processor speed, memory capacity, and to some degree power consumption problems to be engineered towards an

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Application Centric Approach:

- + Very natural to use
- No uniform, cross application storage model to organize data

Nested folders:

- + Familiar to users and span application
- Not effective to use when managing data, while engaging in a task on PDAs (consider sorting photos on a PDA into categories such as 'family,' or 'excursion to downtown')

increasingly lenient design environment, display dimensions remain small by design. One consequence of the small viewing size is a frequent swapping of information between the screen and underlying storage while engaging in a task. For users to recall information that was dismissed from the screen, they require a model of how the off-screen information is logically organized. Two such models dominate today's personal digital assistants (PDAs). One model is to retain the desktop computer's nested folder arrangement (for example, the nested folder model of Windows CE). The other model is to be entirely application centric, leaving display and storage management to each application. Calendar application of Palm OS, for example, is accessed only through the Palm calendar application.

In the physical world we often use piles as transitional organizational structures [3]. Piles were also introduced to computers with the Notecards [2] and HyperCard [1] systems, and other applications [4,5]. Prompted by these precedents we implemented an approach we call Piles Across Space (PAS). We allow users to conceptually flick data unit beyond the screen with their stylus or finger. The data unit is thereby placed on imaginary piles that surround the space around the PDA screen. PAS specifically addresses the issue of managing a limited amount of data that is relevant during a particular task. We rely on the human capacity to remember spatial placement of piles. The imaginary piles can, of course, be retrieved at any time with the flick of the stylus.

In this paper, we will introduce the design of PAS system. We will first sketch the single-user PAS system. Then our discussions will be extended to the multi-user PAS system and related usage scenarios.

Piles Across Space

Figure 1 shows a sketch of the idea behind PAS. The figure shows an example of organizing photos using PAS. Offscreen imaginary piles hold stored photos. Arcs in the corners of the screen are pile markers, which remind the user of the piles' existence. These pile markers also serve as handles to retrieve piles.



Figure 1. View of PAS screen with imaginary piles

Information units that PAS can manage include not only photos, but also voice recordings, hand-drawn memos, video clips, or text. The system animates the flicked items to follow the trajectory that the stylus motion implies. The information unit appears to float off the visible portion of the viewing plane, it leaves behind a partial circle, the pile marker, to remind the user of the information's continued existence. Note that we do not place textual labels with the pile markers. Our goal is to dedicate as much screen real estate to the user's central task as possible.

As users flick more information items towards a pile marker they will observe its arc slowly increasing in

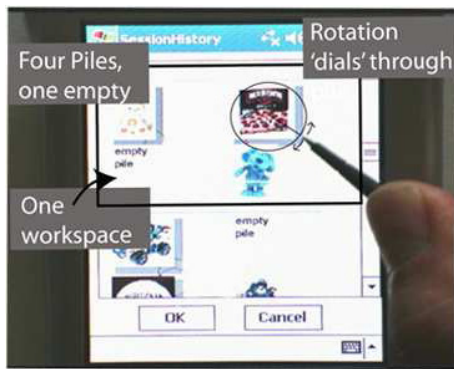


Figure 2. The workspace history browser

thickness to indicate that information is accumulating on that pile. Multiple piles can surround the PDA. A quick flick from within the pile marker inwards toward the screen retrieves the contents of a pile. This interaction replaces the content of the working area with the items of the recalled pile. The displaced items return to the pile from which they were themselves retrieved. If items were never part of a pile, maybe because they were newly created with the PDA, then the displaced items are stored in a special mother pile at the bottom of the screen.

User Interactions

We call the screen layout of Figure 1 a workspace. Workspaces are automatically saved. Each workspace remembers its constituent piles and their virtual locations in space. A special browser (see figure 2) can be used to display summaries of workspaces. Once the user has identified a workspace they wish to work on, they instruct the workspace history browser to reinstate the chosen workspace. The PAS system retains both the composition of items that constitute each pile, and the layout of piles in a workspace. The central area of the screen is called the working area. It contains the information that is currently the focus of the user's attention. Users may accumulate any number of workspaces, all of which they may recall. At any given time, however, only one workspace is active. Recalling a workspace restores the constituent piles to their most recent positions, and recreates the layout of items in the work area.

Data Model

Piles are the central conceptual model in PAS. A special mother pile at the bottom of the screen is an organizationally neutral ground. It holds newly added

items and receives displaced items that are not members of at least one pile. Items may belong to multiple piles at the same time. Any item deletion from a pile only affects the item's membership of that pile.

Multi-User Piles Across Space

PAS is a facility for 'juggling' data when screen space is limited. Beyond this purpose, our implementation extends into three directions. First, we enabled sharing off-screen piles with other PDA users through wireless connections. Second, we implemented the ability to move piles between a PDA and a large wall mounted or table-top display 1. In the following sections, we will present use two sharing scenarios to elaborate these two directions of the Multi-user PAS. And third, we implemented examples that treat off-screen piles as input queues to computing services. One example of the latter would allow the user to fling text to a particular corner of the PDA's screen. The text would thereby be submitted to a search engine². Another example is to flick a document to a corner of the screen and thereby trigger a printing service. All these extensions have been instrumented in our PAS system.

Sharing scenario 1: wireless P2P operation

We now turn to scenarios where a small group of co-located PDA owners wish to operate on piles together. For example, consider a returned traveler reporting on a trip while showing photographs. Traditionally, the story teller comments on each photo as he starts passing it around. A stream of images makes its way around the circle of listeners as the story unfolds. The further down the chain, the further out of phase with the story a listener is once a photo arrives. This problem could be remedied through a single large display that everyone views. But this solution has

shortcomings too. One is that such a central gathering place is often not available when the mood strikes to show photos; a restaurant venue, for example. Another is that listeners often have differing interests in any given photo.

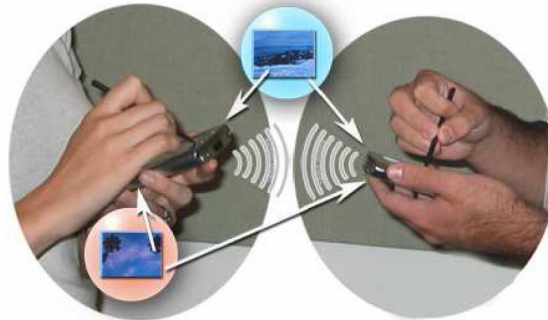


Figure 3. Two PDAs share two virtual piles.

We try to provide a better solution by enabling PAS to share virtual piles among PDAs. This facility allows participants in the above scenario to look at the photos at their own pace. Figure 3 shows how two users interact through the peer-to-peer (P2P) facility of our system. They are sharing two piles, symbolized by the circles with the ocean photo and the palm tree sunset. The current implementation uses ad hoc wireless (WiFi) networking for inter-PDA communication. Note that a given pile is not necessarily located at the same place along the edge of each PDA's screen. For example, for the participant on the right, the ocean pile is logically located at his upper right, while the same pile is located at the upper left for the participant on the left side of the Figure. The model is for the participants to agree on a pile position in space by pointing out to each other verbally where they intend to place the pile. This way they can then communicate about the information during subsequent verbal interactions. An intuitive use

of PAS is thus for each participant to place a pile marker such that it references its pile's imagined place in space. The system does not, however, enforce such alignment. At least in the current implementation there is no sensor that would detect where participants point as they agree on a pile.

Pile sharing is initiated by the person who has created the pile. The user activates sharing from a context menu (stylus point-and-hold). This action triggers the searching for all PDAs within wireless range. Each PDA owner has the option of accepting or rejecting the pile. Everyone who agrees to the sharing arrangement then 'sees' the pile. As part of the acceptance action, each recipient user is free to place the newly shared pile anywhere along the edge of his screen by dragging an automatically created pile marker into position. From then on the user can interact with the shared pile just like as with a pile in single user PAS. Once a pile is shared with a set of participants, all participants can thus add and remove items from the shared pile. Each such event is broadcast and executed by all participants' PDAs.

However, even though every participant can act on the pile, the original pile is considered to be the master pile. All additions or removals are atomic transactions; there is no notion of serializability and concurrency control, since the user scenario is of a few people working in reasonably close proximity.

Once a participant physically moves out of radio range from the others, the issue of integrity control is more pressing. We want to allow each participant to continue working on the shared pile while out of range. This permissiveness obviously leads to inconsistent copies.

Rather than introducing a complex reconciliation protocol, our implementation uses optimistic concurrency control with a centralized master copy. The following occurs when the distant participant reenters radio range with the pile owner: Both parties see a dialog box on the screen, informing them of the conflict. Each has the choice of accepting or rejecting the other's pile version. If both decline, the pile sharing arrangement is terminated. Each party retains its own version. If the owner of the master pile accepts the changes made by the non-owner, the master pile is modified by merging the non-owner's action log with the owner's log. If the non-owner then does not accept the owner's changes, pile sharing is discontinued. If the non-owner accepts the changes made by the owner, but the owner declines the changes made by the non-owner, the non-owner's PDA will simply copy the owner's current master pile state, and the sharing arrangement continues.

Sharing scenario 2: tabletop display

Beyond the P2P capability described above, we integrated our Piles Across Space implementation into the environment of a DiamondTouch tabletop display. This apparatus is a (diagonally measured) 107cm table whose surface is a 1280x1024 pixel touch-sensitive, top-projected display. The table is more than a large, horizontal display surface in that it allows up to four people to touch the surface of the display at the same time, and to drag items across the table's expanse. Through capacitive coupling across the pads that participants sit on, the attached computer can distinguish touch from all hands, even when they touch the surface simultaneously.

We use this table in the context of our research on using PAS as a tool for field biologists. One scenario is of students and professional biology researchers returning to their field station from a day outdoors. They are seeking advice from experts, or simply want to share photos or interesting measurements with others. Our vision is for them to flick piles of information from their PDA to the table for others to see, manipulate, and return to the PDA. Figure 4 shows an overview and a screenshot of the tabletop arrangement. The PDA communicates with the table computer through ad hoc WiFi. The interaction model between the two devices is more loosely coupled than our inter-PDA P2P approach. Information is simply transferred between the two devices, rather than continuously maintained through shared piles. The light colored area on the table (near the arrows in Figure 4) is called the teleportation area. The PDA's screen in Figure 1 shows the word 'Table' along the left edge. This is the small device's equivalent to the table's teleportation area. To transfer either a pile or an individual information item from the PDA to the table, one drags it to the PDA's teleportation area. As soon as the respective icon is dropped, it appears in the table's teleportation area. Anyone seated at the table can then drag the pile or item freely around the surface of the table display.

The detailed view of figure 4 also shows a number of items scattered across the table. All came from PDAs running PAS. As the superimposed annotations show, the lower left item is a text file. Above it we see a sound file. An entire pile lies above the sound file. Piles can be teleported to the table, and modified, created, or destroyed by groups of users at the table, and then transferred back to the PDAs. At the right edge of the

table we see a sound file being played; an audio control has popped out of the main window. The rest of the items on the table are individual photos that were flicked to the PDA's teleportation area.

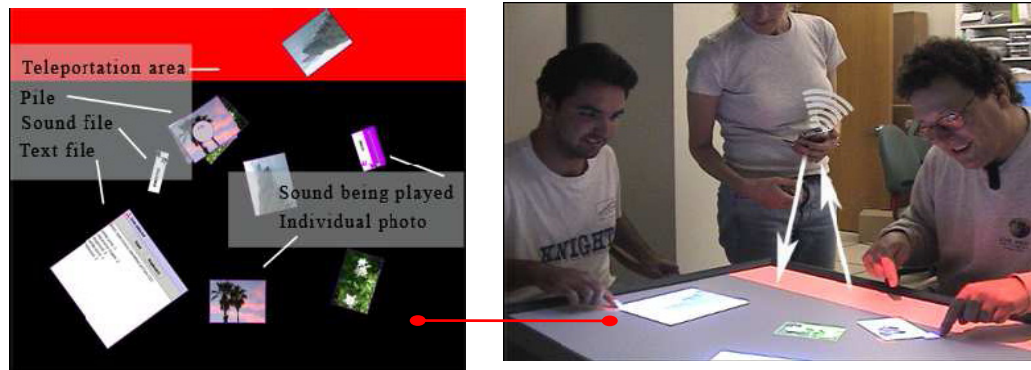


Figure 4. PAS with tabletop display.

Conversely, piles or individual information items that table operators drag to the table's teleportation area accumulate as a special pile on every PDA that is in range. The presence of new information is indicated on the PDA by having the lower portion of the PDA's teleportation area highlighted. The device's owner can then drag it onto the work area.

Conclusion

We presented our design and implementation of the Piles Across Space system. This facility breaks through the screen real-estate barrier that PDAs impose on their applications. Users flick information units towards the edge of the screen where it disappears as if joining one of several imaginary piles that are located off-screen. The system works for individual users as well as for small work groups with multiple PDAs. It can support co-located operation, either among multiple PDAs or between PDAs and a shared tabletop display. Multi-User

Piles Across Space allows users to share the contents of virtual piles and to work together to organize information even given the screen real estate constraints of PDAs.

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