Exploring Pen and Paper Interaction for Task Management in AR

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Abstract

This paper explores opportunities for using augmented reality (AR) to blend paper-based materials with digital content for hybrid task management. Despite the increasing popularity of digital tools, traditional paper-based methods remain popular for task management, as confirmed by a survey (N=153). Rather than choosing between the two, we view AR as a valuable asset in facilitating a hybrid approach, given its ability to overlay digital content onto physical materials. We conducted an ideation workshop and compiled the findings into design requirements for future development.

CCS Concepts

• **Human-centered computing → Mixed / augmented reality**; **User studies**.

Keywords

Task management, Augmented reality, Pen and paper, Hybrid interface

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1 Introduction

Task management is an important focus of personal information management [11]. Though digital tools, such as Microsoft Todo[1] and Google Calendar[2], are developed to support effective task management, paper-based physical materials, such as sticky notes and planners, are still irreplaceable and used due to their unique benefits and afforadance [7, 9, 10, 19, 23, 24]. It is further reflected by several large-scale surveys ranging from 2009 to 2020 [8, 17, 18, 25]. To confirm whether these findings are still valid recently, we surveyed 153 participants through Prolific[3] (a crowd-sourcing platform designed specifically for online academic research) and local universities. The result, as shown in Figure 1, confirmed that 75.8% of respondents are mixing the use of physical materials and digital software (rating between mostly physical and mostly digital), and they encountered challenges like no synchronization between these two media. More specifically, 32.0% of respondents used paper-based physical materials and digital software almost equally (rating between slightly more physical and slightly more digital).

Rather than letting people choose the digital way or the pen-and-paper way, we aim to utilize both benefits through augmented reality (AR) to overlay digital content on physical entities. It is also supported by our survey that 56.2% of respondents wanted to combine the benefits of both media (Figure 1). Additionally, AR could potentially enhance the current task management experience with situation awareness, displaying the tasks adapted to the situation (e.g., work list when sitting at the desk, shopping list in a grocery store). Researchers have investigated hybrid interfaces of AR and paper for different domains. For example, the experience of reading paper-based materials can be enhanced by adding annotation [12, 15], extending physical content [4], and supporting multimedia [5, 12, 16] in AR. Beyond paper documents, Subramonyam *et al.* [20, 21] augmented digital information on top of sticky notes for data analysis. Moreover, dynamicity and interactivity could be given to static paper through AR to integrate tangible interfaces into digital workflows, for example, reading digital photos through a physical album [6] and interacting with data visualization through physical paper sheets [22]. However, task management is a popular yet complex process that involves multiple phases, and it is still unclear how to combine paper-based and digital materials in AR for a better task management experience.

[1]https://todo.microsoft.com/tasks/
[2]https://calendar.google.com/
[3]https://www.prolific.co/

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2 Solicidating Designs: Ideation Workshop

Therefore, to explore the designs for creating a hybrid task management interface with AR capabilities, we designed and conducted ideation workshops to explore various design options.

Given the expressive power of sketching and the novelty of our idea, we adapted the idea of conducting ideation workshops with a sketching activity.

Participants. From the survey distributed in local universities (33 respondents), we invited respondents who have strong mixed task management practice (with a proportion ranked between 3 and 5) or a strong motivation to combine the usage of physical materials and digital software for task management (motivation rated higher than 3). In total, 20 respondents (W1-W20; 13 male; 7 female) joined workshops aged 18 to 34 years (18-24: 7; 25-34: 13). We then grouped the participants into five groups of four. Group-based ideation could help participants build on others' ideas and motivate shy participants to engage more actively [13, 14].

Setup and Apparatus. The workshops were held in office rooms in local universities, as shown in Figure 2 (b). We provided different

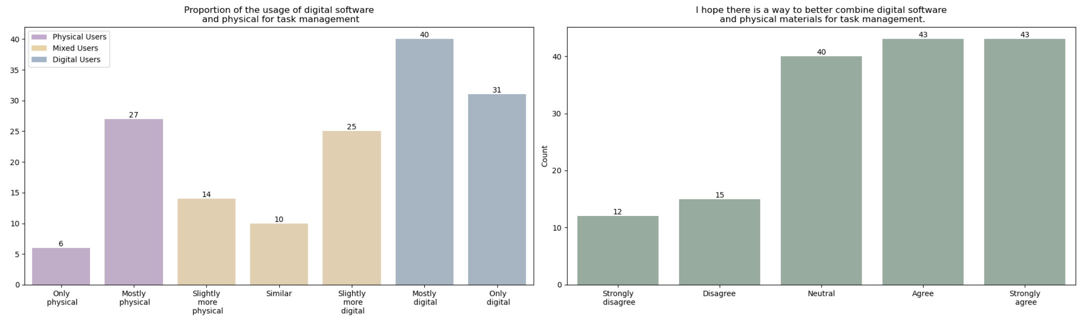

Figure 1: The figure shows two bar charts: the distribution of people using physical materials and digital software (left) and the rating of the motivation to combine physical materials and digital tools (right) for task management, ranging from only physical (1), mostly physical (2), slightly more physical (3), similar (4), slightly more digital (5), mostly digital (6), and only digital (7). We represent people who rated only physical and mostly physical as physical users; slightly more physical, similar, and slightly more digital as mixed users; mostly digital and only digital as digital users. The motivation for using hybrid task management tools is a five-point Likert scale from strongly disagree (1) and strongly agree (5).

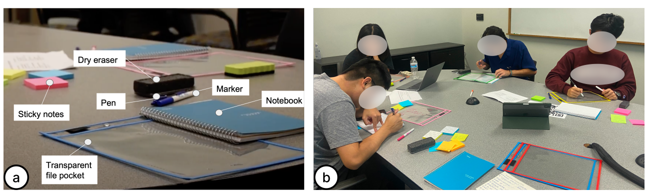

Figure 2: The figure shows (a) the materials used in the workshop for each participant: a transparent file pocket, a notebook, a marker, a pen, a dry eraser, and stick notes, and (b) an example of a workshop setting, four people in a group.

materials for participants to express and sketch their thoughts (Figure 2 (a)). In particular, we provided sticky notes and a notebook (participants could feel free to tear off the paper as a single sheet of paper) for each participant based on the top three frequently used physical materials for task management. As Bressa *et al.* [2] suggested, we provided transparent file pockets and makers to help participants sketch their designs with AR content. Participants could draw the content displayed in AR and overlay the file pocket on top of any physical objects, such as the notebook (Figure 2). To generate more ideas that are not limited to the office room environment, we encourage participants to sketch the context and additional objects outside the lab. The workshop lasted 1.5 - 2 hours, and participants were compensated with a $20 Amazon Gift card.

Procedure. We first introduced the background and goal of the workshop to the teams. We then provided a warm-up exercise to familiarize participants with the design process and sketching using transparent files [2]. Participants were required to sketch their designs based on the idea we gave. Participants then sketched their designs using the transparent file and physical materials and took pictures of each idea in context. To help participants organize and brainstorm their ideas, we break down task management into three phases based on previous work [1, 11]: **task planning** (define necessary tasks to achieve a goal, such as creating todo and setting up reminders), **task tracking** (monitor tasks progress and update, such as checking the remaining task), and **task closing** (complete and evaluate tasks, such as reflecting outcomes and performance). In each phase, we started by defining the current phase and emphasizing the requirement of combining physical materials and digital software using AR for task management. Participants were then given 15 minutes to brainstorm, sketch their ideas, and take pictures of their designs, as practiced in the warm-up exercise. We encouraged participants to brainstorm as many ideas as possible, and the study conductor would remind them to take pictures of their designs at the last minute. After individual brainstorming, the study conductors reviewed each participant's picture one by one. The participants then shared and explained their designs with the others. Afterward, participants had 10 minutes to clarify their own ideas or build on and comment on the shared ideas. After running through all three phases, we have a debriefing session for participants to discuss the things missed previously.

3 Results

In total, we collected 125 design thoughts. Examples could be seen in Figure 4. We audio-recorded the whole workshop process and transcribed the audio into scripts. The three authors iteratively performed open-coding [3] on the workshop scripts together. Some codes were explicitly mentioned by the participants, and some were coded by the authors after analyzing their ideas. When we faced a conflict, we shared our reasoning and discussed it together to find a resolution. As shown in Figure 3, we coded each idea from the following three aspects: **function**, **presentation**, and **interaction**.

Function. To better understand how tasks could be adapted to each media, we break down task management into different functions.Function involves two components: the **phase** and the **unit**.

Phase describes the idea's task management stage. Based on previous literature and ideas proposed by participants, we proposed three phases: **task planning**, **task tracking**, and **task closing**.

- **Task Planning (48)** represents the stage when people plan their tasks, *e.g.*, set the time and priority at the very beginning.
- **Task Tracking (26)** represents the stage when people execute and track the progress of their tasks.

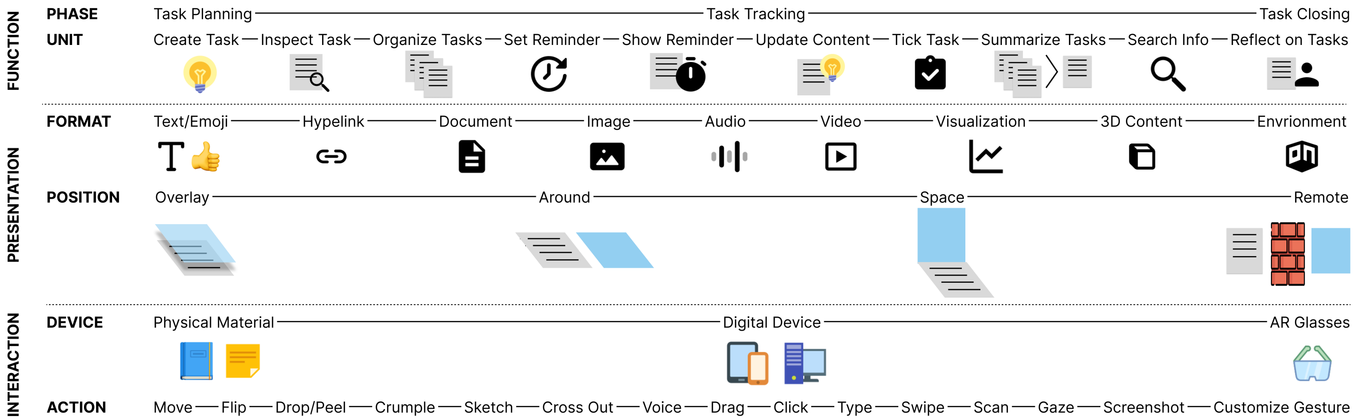

Figure 3: The figure shows the three design aspects of hybrid task management using AR: function, presentation, and interaction.

- **Task Closing (51)** represents the stage when people reach the deadline of a milestone of their tasks and check whether the tasks have been finished and reflect the whole process.

Unit describes the fine-grained action for task management.

- **Create Task (25)** represents creating the metadata of the task for the first time, *e.g.*, content, subtasks, deadline, etc.
- **Inspect Task (30)** represents checking out the details of tasks, *e.g.*, the deadline, the subtasks, the progress, the dependency, the staffing, and documents or multi-media files related to tasks.
- **Set Reminder (4)** represents setting reminders for tasks. The reminders can be set based on location, time, or other things.
- **Show Reminder (10)** represents showing the reminders of tasks. The behavior can be passive, which means it can be triggered by the time or location instead of the users' actions.
- **Update Content (3)** represents updating the content of tasks.
- **Tick Task (12)** represents the behavior of crossing out the tasks or ticking the tasks after finishing or removing them.
- **Organize Tasks (19)** represents organizing multiple tasks to make them neat according to certain criteria. For example, reorder tasks based on time, workload, priority, and dependency.
- **Summarize Tasks (13)** represents checking what tasks have been finished and what are left.
- **Search Info (3)** represents searching information of previous tasks for reuse or reflection.
- **Reflect on Tasks (6)** represents reflecting on task management and execution.

The phase and task actions are closely related. For example, users are more likely to create, inspect, and organize tasks as well as set reminders in the task planning phase.

Presentation. The second aspect is *presentation* and includes **format** and **position** components. Due to the interactivity of digital layers added using AR, we can add not only text to our tasks but also multimedia like images and videos and even data visualization to assist task management. Moreover, with the power of spatial computing with AR technology for task management, the content is not necessarily bound to a fixed 2D canvas.

Format describes the format of the additional content shown in the AR. For example, the additional content includes *text/emoji* (91), *data visualization* (23), *hyperlinks* (2), *audio* (5), *video* (2), *document* (2), and *image* (3). Beyond 2D content, 3D digital content could be presented in AR, such as *3D objects* (2) and *virtual environments* (1).

Position describes how to show additional information in AR. There are four ways to position the additional context: *overlay* to the physical materials (*e.g.*, the written task) (14), *around* the physical material (57), same *space* to the notebook (12), *remote* to the physical materials (30).

Confirming the format is also essential to designing the position. For example, large content could be placed in space or remotely, while important details and visualization should be placed near the notebook. Moreover, context-related tasks usually require presenting additional information remotely from the physical notebook.

Interaction. The last dimension is *interaction* and involves two components: **device** and **action**. By combining unique actions from various devices ranging from physical materials to AR, we have more choices in interacting with hybrid task management tools. Moreover, interaction helps update and synchronize task status between physical and digital space.

Device ranges from *physical materials* (40) such as sticky notes and notebooks to *digital devices* (4) like smartphones and laptops to *AR glasses* (90). People could utilize different devices for task management. For example, the idea of sketching their to-do lists on paper and then synchronizing them or creating digital versions of those tasks in AR.

Action describes how users interact with the hybrid task management system. Based on the previous example, the action performed with the physical materials is *sketch*, and the action performed in AR is a *scan* (implicitly). In total, we identified 15 types of interactions from the ideas participants proposed. Some interactions are associated with physical material: *sketch on paper* (29), *drop/peel* (4), *move* (3), *cross out* (2), *flip* (1), and *crumple* (1). Some interactions are associated with AR glasses: *scan* (61), *gaze* (14), *voice* (6), *AR sketch* (5), *drag* (3), *click* (3), *customize gesture* (2), *swipe* (2), and *screenshot* (1). Noted that *scanning* has the highest count as it is an essential action that helps synchronize between physical and digital worlds. There are additional interactions associated with

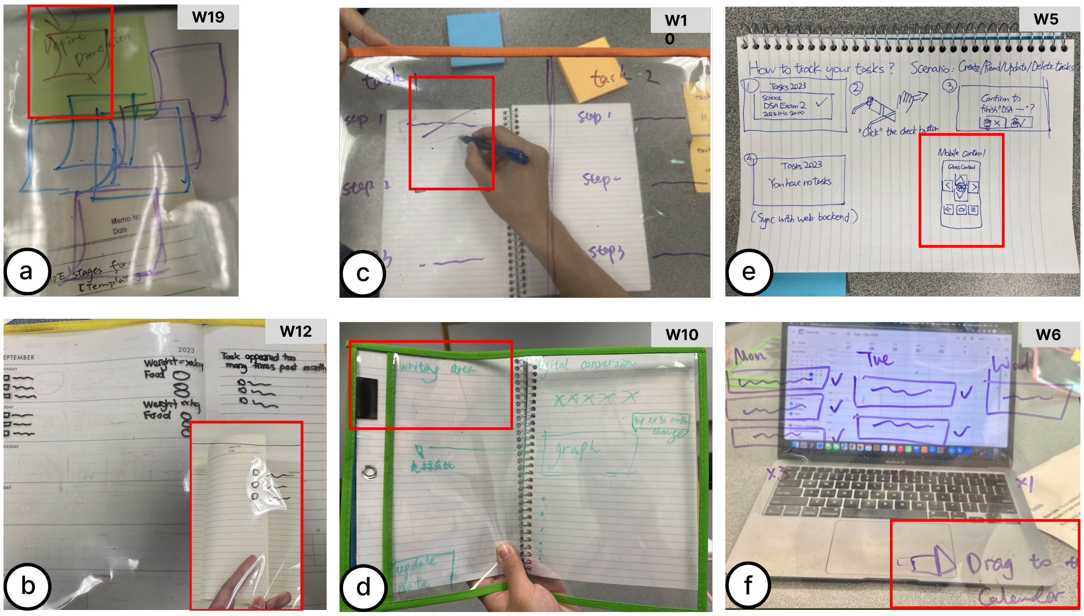

Figure 4: The figure shows some design concepts proposed by workshop participants. (a) shows that the peel interaction of one sticky note in the real world leads to creating one digital note in the digital world. (b) shows that flipping the paper can see the weight change on the notebook. (c) show "real" writing on the paper using a pen, and then AR detects the strokes, while (d) shows the "fake" writing on the paper, and AR detects the movement of the pen. (e) shows that using a mobile phone to control some task management interactions and (f) shows dragging the to-do from AR to the calendar application on the desktop.

other digital devices (*e.g.*, mobile phones, digital notebooks): *type* (3) and *digital notebook sketch* (1).

Different input devices could provide unique affordance for interaction. For example, we can flip a book while other devices cannot. On the other hand, some interactions are shared among all devices, such as sketching. Interestingly, we can see a clear trend that people prefer to sketch on paper (29) rather than in AR (5) or other devices (1) , which might be carefully designed to avoid confusion.

Detailed design thoughts and codes can be found at the project webpage[4]. Based on these codes, we distill the following design requirements for future development.

Support bidirectional synchronization. The task created on the paper should also be created on the digital side, while the changes in task status on the digital side should be synchronized on the paper through the AR overlay. We found that most of the physical interaction lies in the task planning phase (23/39), particularly in creating task unit. In creating task unit, more than half of the design ideas are based on sketching using a pen (15/24). As a result, the system should integrate seamless handwriting recognition and digital translation while maintaining real-time updates between physical and digital representations.

Support better time management. In task planning and tracking, users often struggle to estimate time requirements and follow schedules, especially if using only physical materials. The system should provide functions for adding due dates, visual cues for deadlines, and adaptive scheduling recommendations based on past task completion times through AR (14/125).

Support context-aware reminders. In task tracking, timely and relevant notifications can help users stay on track (14/125). The system should recognize the background context (6/14) and emotion (5/14) to provide intelligent reminders. For example, if a user is in the grocery store, the system should remind users of the task to be done there. Furthermore, if a user is behind schedule, the system could encourage and suggest rescheduling or breaking down tasks into smaller steps. Lastly, AR overlays should also highlight pending tasks directly on the paper to reinforce engagement.

Support summary and reflection. In task closing, users benefit from reviewing completed work and identifying areas for improvement (19/125). The system should generate automated summaries of completed tasks, highlight productivity patterns, and offer insights into efficiency. Interactive visualizations of past activities could help users reflect on their workflows and make informed adjustments for future planning. A paper-based summary, possibly generated through AR-enhanced visualization, could reinforce reflection and learning.

4 Conclusion

This paper presents the potential of combining pen and paper and digital tools through the use of AR technology with ideation workshops of five groups of four to explore various design options. In the next step, we will continue to develop the system based on the design requirements and evaluate it with a user study.

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