An Evaluation of Hybrid Stacking on Interactive Tabletops

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ABSTRACT

Stacking is a common practice of organizing documents in the physical world. With the recent advent of interactive tabletops, physical documents can now coexist with digital documents on the same surface. As a result, systems were developed and studied which allow piling of both types of documents with the physical documents being placed on top of the digital ones. In this paper, we study the concept of true hybrid stacking, allowing users to stack both types of documents in an arbitrary order using a hybrid tabletop system called StackTop. We discuss the results and derive implications for future hybrid tabletop systems with stacking support.

Author Keywords

Interactive tabletop displays; stacking; piling; hybrid physical-digital interaction; peripheral displays; multitouch.

ACM Classification Keywords

H.5.m. Information Interfaces and Presentation (e.g. HCI): Miscellaneous

INTRODUCTION

Stacking or piling are two very common techniques for structuring and managing workplaces in the physical world [8,11,12]. While being very common in the physical world and also having been transferred to the digital world [1,3,5,12], the availability of stacking in mixed digital-physical environments (e.g. on interactive tabletops) is still limited.

The use of these techniques in hybrid environments has been subject of an extensive user study by, among others, Steimle et al. [16]. During the study, they found out that
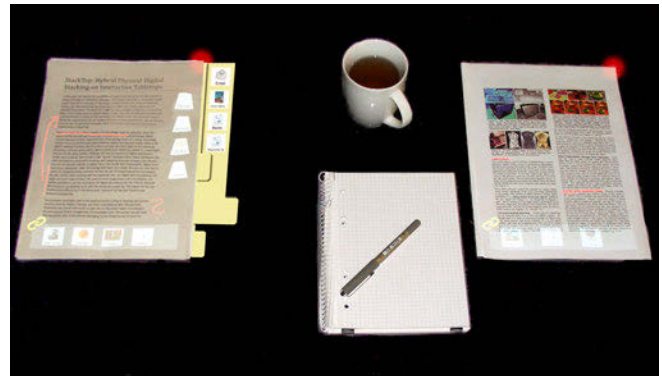
Figure 1: StackTop facilitates hybrid stacking on interactive tabletops by providing awareness and means of access to stacked documents.

piling, grouping and sorting are also applied in hybrid settings by the participants. However, the system they used was limited in a way that it was only possible to build piles where the digital items are at the bottom and the physical ones on top. Building upon this, Khalilbeigi et al. [7] proposed a set of techniques to support hybrid piling on tabletops. While inspiring, these techniques are also restricted to piles with separate digital and physical parts. Thereby, the power of expression of hybrid piles is limited compared to their purely physical or digital counterparts.

While hybrid piling (i.e. the pile consists of separate digital and physical parts) has been studied in the past [7,16], the use of hybrid stacking has, to the best of our knowledge, not been studied yet. In [14], we contributed Stack-Top (see figure 1), an integrated set of visualization and interaction techniques for *true hybrid stacking*. Stack-Top allows seamlessly interweaving digital and physical documents in one stack and supports users to navigate, search, and reorganize both document types within the stack. StackTop will serve as basis for our study. Our research is therefore motivated by the following research questions:

1. Do users employ their natural practices of stacking in a true hybrid environment where they can intertwine both physical and digital documents?

2. How do they perceive the concept of hybrid stacking and how do they perform hybrid stacking in practice?

As a result, our contribution in this paper is twofold:

1. The first user study examining the concept of hybrid stacking qualitatively and quantitatively. We do so by employing our previously developed StackTop [14] system.

2. Based on the results, we revisit our design and derive implications for the design of future hybrid stacking systems.

The rest of the paper is structured as follows: We start with a short introduction of the system used during the study. We then describe the study and discuss its results. We conclude with a set of design implications and a review of our research questions.

RELATED WORK
Purely physical stacks are very common on today's workplaces. As a result, techniques have been developed to digitally support interaction with those stacks. Fujii et al. [3] developed a tangible search concept that tracks the objects in a physical stack so the user can move his finger on the side of the stack and view thumbnails of the objects contained the stack. Iwai et al. [5] developed the limpid desk. It resolves the occlusion between multiple piled physical documents by projecting the content of the physical document touched by the user on top of the pile. However, these approaches are limited to physical documents and do not take into account hybrid media usage.

On the purely digital side, stacking is also very prominent: Mander et al. [12] as well as Agarawala [1] developed and employed a piling metaphor to facilitate digital document organization. Moreover, piling concepts were developed [2, 15] that do not need to put documents directly on top of one another. Jakobsen et al. [6] explored different strategies to work with overlapping or tabbed documents on a screen. Piling was shown to deliver a high performance in retrieving the relevant documents, underlining the importance of piling.

Steimle et al. [16] conducted an extensive user study to understand how natural practices of working with piles transfer to hybrid digital-physical scenarios on interactive surfaces. They found out that concepts common in the physical world, like piling, grouping or sorting, are also applied to hybrid settings. They observed that participants frequently build hybrid piles by placing digital items first and then putting the physical ones on top. Building upon this, Khalilbeigi et al. [7] proposed a set of techniques to support hybrid piling on tabletops. While inspiring, these works only support hybrid piles that consists of two distinct digital and physical parts.
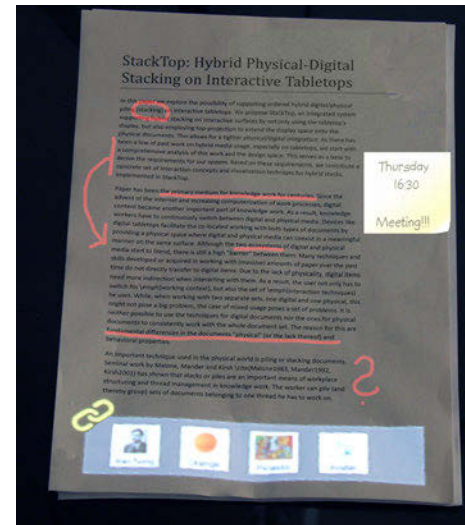

Figure 2: Visualizaion techniques for hybrid documents

Efforts have also been made to augment individual documents with digital projection or input. The DigitalDesk [17], FACT [10] and Paper-Top [13] are combined projector-camera assemblies that can project onto printed documents. They enable the user to interactively add digital content [10, 13, 17], show animations [13] or do highlighting while maintaining an digital copy of the physical document [10]. EnhancedDesk by Koike et al. [9] used a projector to display related digital content next to physical documents. However, these systems aim at augmenting paper documents in an individual level with additional digital facilities. Supporting only linked content or annotations, they do not allow for hybrid stacking of documents.

TABLETOP ENVIRONMENT
For our study, we use the StackTop [14] environment, which is an integrated system supporting hybrid stacking (a loosely coupled ordered set of physical and digital documents) as well as hybrid documents (a tightly coupled set consisting of one physical object and multiple digital objects).

Generally, standard multitouch gestures, like moving, zooming, rotating are supported throughout the system.

Hybrid Documents (Tight Coupling)
In order to support a wide spectrum of digital document augmentation, StackTop differentiates two types of digital objects: Annotations and linked documents. The first category is for instance digital pen strokes or virtual post-it notes. Just like real pen strokes or physical post-its, it is sensible to show them where the user actually drew/placed them in their full size (see figure 2). For the second type, however, the exact location on the document is usually not important as they are associated with the whole document and not a specific part of it. They can therefore be visualized in a reduced form at free spots on the document in order to minimize visual clutter.

Figure 3: Direct access for linked documents

Figure 4: Register, idle (left) and pulled out (right)

StackTop provides a "link bar" at the bottom of all digital or physical document, where documents that should be linked can be dropped (See figure 2). To view the linked documents, the user can either employ the remote peek gesture (for a quick, temporary view) or tap one of the icons to get a permanent view next to the physical document. As shown in figure 3, the content is displayed in a "bubble" and can be viewed. To remove an item, the user can simply drag it off the link bar to the tabletop.

Annotations are created in different ways, depending of which type they are: Pen-based annotations are created by directly drawing with a digital pen on the document. For other digital objects, StackTop differentiates between the type of the digital object to avoid conflicts with stacking: Annotation-object like a digital post it can be directly dragged from the tabletop surface onto the document, or from one document to another and it then treated as annotation. If other digital objects, like documents, should be used as annotation, the user has to link them first and then move them from the link-bar to the final position on the document. While this seems a bit complicated, it enables faster interaction for the common case of stacking documents, and using, for example, post-its as annotation, by directly moving them on the document.

Hybrid Stacks (Loose Coupling)
Hybrid stacks within StackTop can consist of digital, physical and hybrid documents. StackTop indicates the augmentation of a stack with a red glowing corner (Stack indicator). Stacks have some typical operations: building the stack, browsing and accessing its items or documents and reordering the stack. For each of the tasks, StackTop provides suitable techniques:

Building the Stack
For physical documents, stacking and unstacking is supported similar to conventional physical stacking. To add
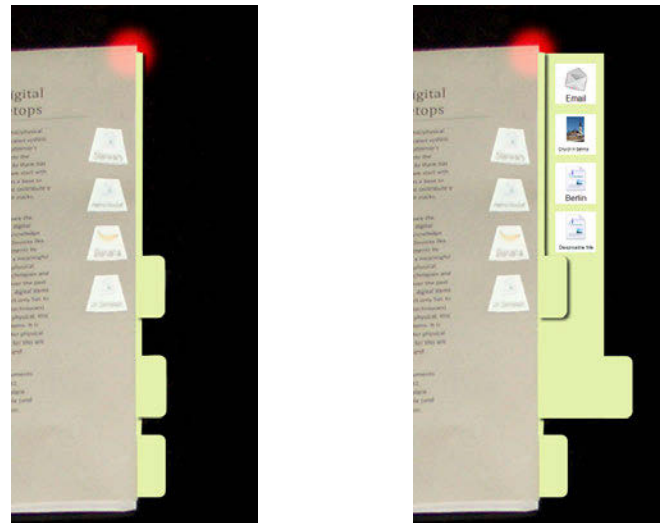
or remove digital documents, the user can either directly drag them on or off the stack or use a teleport gesture [14]. In both cases, the digital documents are placed at the topmost position in the stack. In order to minimize visual clutter, the digital documents are shown as icons.

Browsing and Accessing
StackTop offers three techniques:

In-place Access allows directly accessing the digital documents stacked above the topmost physical document by showing the digital documents as icons at a free area in the margin of the document (see figure 4). The user can take a look at the documents by dragging them off the stack, resulting in the full object being shown on the tabletop. Further, StackTop provides a remote peeking gesture, a bi-manual gesture where a single finger touch references a target object (e.g. the icon shown on the document) and the other hand can span a display area with two fingers for temporary inspection (see figure 5).

Registers use the register metaphor known from physical folders and enable local "at the stack" access to the digital content at an arbitrary level in the stack by pulling out the corresponding register. Each register represents a layer of digital documents between two physical documents ordered from top to bottom (see figure 4). Using the registers, it is possible to peek, add and remove digital content at arbitrary levels of the stack. However, when dragging out an object from a register, a copy of the document is created instead of removing the actual object. If the user wants to really remove it, he can use teleport gesture by referencing an empty spot on the tabletop and flicking the digital document out of the register. This allows accessing documents at intermediate levels temporarily without altering the stack.

StackPath gives a complete overview on the stack. The content of the stack is lined up equidistantly along a
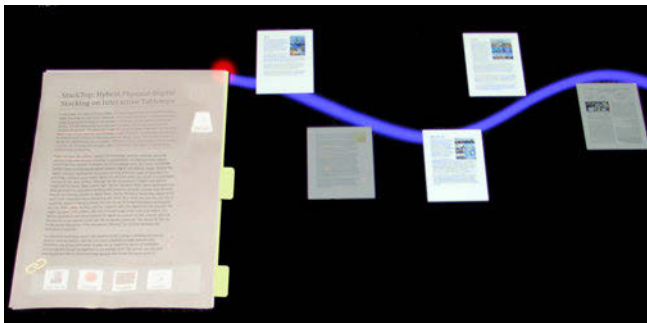
Figure 5: Remote Peek technique

Figure 6: StackPath technique

user-drawn path, starting at the stack indicator. The user can thereby optimally use free space on the tabletop without moving other objects. Physical documents are shown slightly dimmed to signal that not all actions can be performed. For instance, it is not possible to remove them from the stack. Otherwise, StackPath supports the same interactions as the registers (e.g. adding as shown in figure 7).

Reordering
The last operation supported by StackTop is reordering stacks. Depending on the scope of the reordering operation, the user has several options: If he wants to reorder only a specific digital layer, the registers can be used: By dragging the icons within the register, it is possible to alter their ordering. The same holds for the in-place-access on the topmost document. In order to reorder the stack across physical documents, one can either remove a document from one register and add it to another, or use the
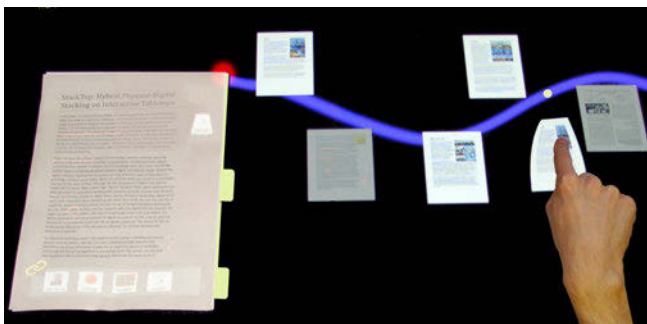

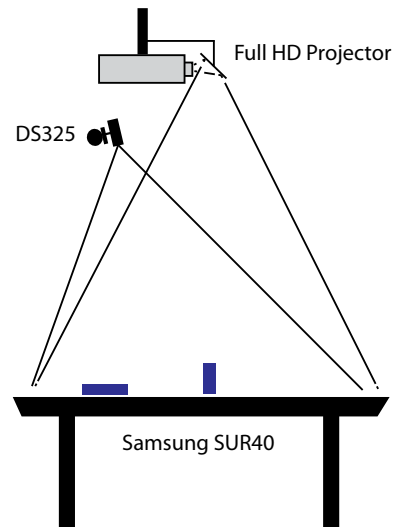Figure 7: Using StackPath for stacking a digital object

Figure 8: Lab setup for our system

StackPath. The StackPath allows for intuitive reordering of the stack by dragging the documents around. However, the physical documents are fixed in their position, serving as skeleton.

IMPLEMENTATION
All described techniques are currently being implemented in a fully functional system written in C# using DirectX. It runs on a Samsung SUR40 tabletop, augmented with a full HD projector and a SoftKinetic DS325 above it. The physical objects are shadow-tracked using standard CV algorithms on the raw IR-image of the tabletop. The projector allows displaying content on the passive physical objects, the DS325 enables touch on them. While we use a two-class display system (high-resolution LCD tabletop plus top-projection), the concept directly transfers to other hybrid settings as well, for instance:

1. LCD-based high-resolution tabletop with passive physical objects and top-projection for document augmentation (our setup)

2. LCD-based tabletop with a set of active eInk or similar displays (on-document visualization can be directly displayed)

3. Completely top-projected environments

USER STUDY
To address our aforementioned research questions, we conducted a user study using the implementation described before.

Goal
The goal of our study was to find out how users would use hybrid stacking when there is a system supporting this concept. More specifically, we were interested to see how well users can grasp the concept of hybrid stacking and how the techniques StackTop offers perform in supporting the users.

Participants

We had 7 participants recruited from our lab (all male, aged between 22 and 33, $\mu = 26.7$). All had at least occasional previous experiences with tabletops. They were not given any compensation for participating in the study.

Apparatus and Setup

The study was conducted using the system described in the implementation section and took place in our lab. During the study, a set of physical objects was present on the tabletop (printed papers, Wikipedia articles and a book) as well as some digital objects (digital wikipedia articles, images and notes). We did not impose a specific task, therefore the arrangement of the objects was up to the user.

Experiment Design

As we were interested mainly in the general perception of hybrid stacking, we let the participants freely use and explore the system. The participants were given an introduction to the system and were allowed to play around with it for about half an hour. During this time, they were encouraged to tell anything they found (think-aloud style). After that, they had to answer a set of questionnaires: NASA TLX to assess the cognitive load of our Hybrid Stacking environment, as well as SUS and AttrakDiff to get additional feedback on the usability of the system. For the TLX, we omitted the temporal demand question, as we did not impose any time restrictions and due to some stability issues with the touch detection on objects.

RESULTS AND DISCUSSION

TLX

In order to assess the load using stack top puts on the user, we employed the NASA Task Load Index questionnaire. The NASA TLX revealed that using StackTop imposes a sub-average load on the user with all values being below 10 (see figure 9). The relatively high value for mental demand is possibly a result of the novel concept which the users had to grasp first. However, as it is still below 10, one can deduce that the concept can be easily understood by casually using the system. The value for frustration can be mainly explained by the touch issues, which is backed by the feedback users gave during the sessions. These issues were caused by the interference between the depth camera and the PixelSense technology and we therefore consider it as an implementation issue.

SUS

The SUS questionnaire revealed a score of 74.28 ($\sigma = 8.93$) for our system, which is above average and indicates a good overall usability.

AttrakDiff

The AttrakDiff [4] questionnaire indicated a very high hedonic quality ($\mu = 1.5$, $\sigma = 0.38$) as well as an above-average pragmatic quality ($\mu = 0.89$, $\sigma = 0.95$). The
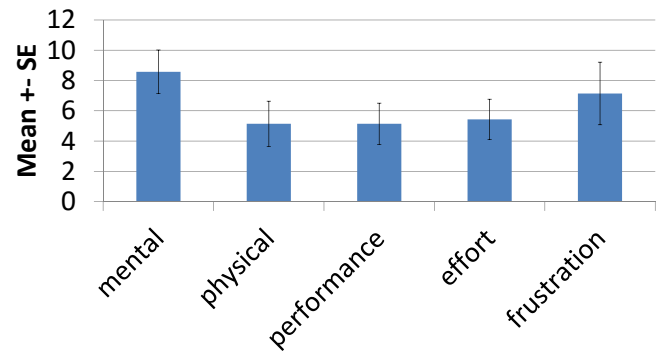
NASA TLX

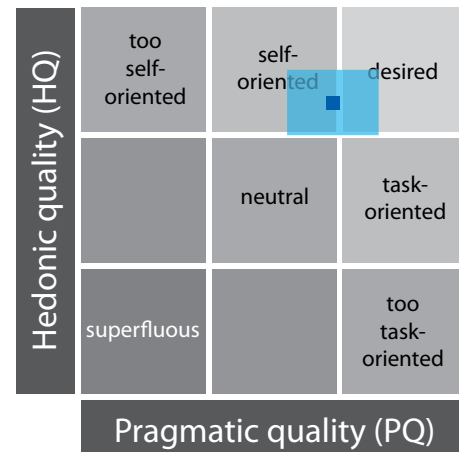Figure 9: TLX results, full scale is from 1 to 20

Figure 10: AttrakDiff portfolio for StackTop

comparably "low" value for pragmatic quality is a result of the system being perceived as more technically ($\mu = -0.42$, $\sigma = 1.49$), see figure 11. One reason for this might have been our lab setup with its unnatural environment and the aforementioned touch issues. The attractiveness score was also showing a high value ($\mu = 1.67$, $\sigma = 0.79$), indicating that users like the system. Overall, the system can be described as creative, innovative and novel, based on the highest ranked attributes (c.f. figure 11).

User-Feedback

All participants liked the idea of hybrid stacking very much. They enjoyed stacking digital with physical objects, e.g. by creating alphabetically sorted stacks which would not be possible to build without stacking support. Despite the overall positive results, participants also had some critical feedback on some of StackTop's features.

Projection on Empty Places Using empty places on the document in order to use physical documents as handle or carrier of digital information was intuitive to all participants, with two participants explicitly mentioning it as positive ("Using physical objects as carrier for digital content is very nice", P4). However, P1 noted that using free areas might be problematic in case the user explicitly wants the area to be free and uncovered. This is a general
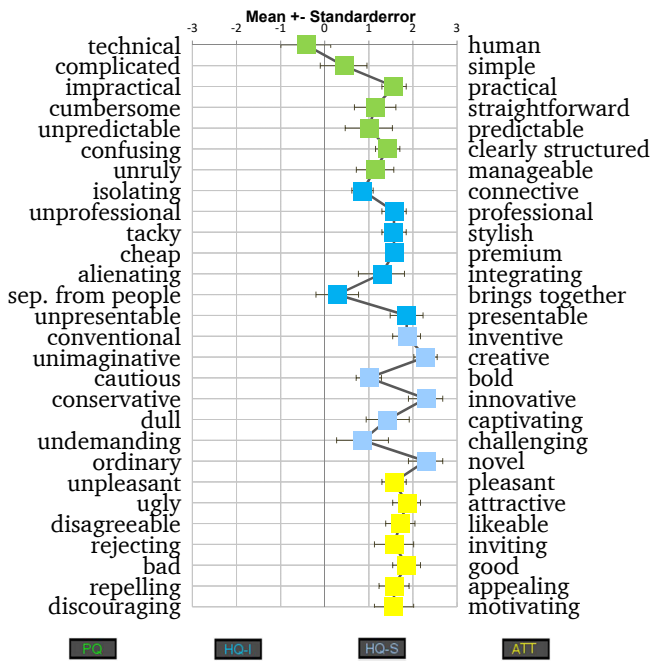
Figure 11: AttrakDiff details

issue with systems projecting on objects not specifically made for projection, as the projection can always interfere with the user's intent. A possible, yet rather inconvenient solution, would be to allow the user to mask certain areas, which then are not used to project content.

User-Drawn Path for Exploration The *StackPath technique* was well received, however, two out of the seven participants found the current way of closing the path (tapping again on the red dot at the stack) too time consuming. The reason for this is, that while we originally thought of StackPath as a means of reorganizing and deeply viewing the stack, participants also used it to get a short glimpse at the stack's content (e.g. P2 said "I just want to quickly look which elements are in the stack, and not interact with the StackPath in any way"). In order to better support this use case, it was suggested to allow closing the path by a single tap on a free spot on the tabletop. However, this solution might lead to problems in case of unintentional tapping (e.g. playing around with the idle hand on the tabletop while looking at the path or reading a document).

Copy on Drag Out Behavior The default *copy on drag out* behavior for the registers and the StackPath was received very negatively. Five of the seven participants preferred a conventional behaviour to be the default, i.e. that the element is actually removed, instead of a copy being created (P1: "Because the system is on a tabletop, one expects the digital documents to be used just like physical documents - the copy on drag out technique doesn't fit into this concept" and "It is more important to alter a stack than not to do it."). Copy on drag out was however noted to be very useful in some cases, but

should then be accessed through a special gesture (e.g. a two-finger pull-out gesture).

Registers The *register metaphor* to access specific layers of a stack was found to be very practical by most participants. Two participants criticized the visualization style as being suboptimal. They found the registers to be insufficient to depict the structure of the stack, because the information where exactly (absolute position) a register is located within the stack, as well as the information how many digital objects are at the given position is not visible. It was suggested to add a more three dimensional representation (e.g. displaying virtual pages between the registers to denote their thickness) to overcome these issues. One participant even wanted direct access to all objects in the stack, without having to open a register or using the stack-path.

Extensions Also, the participants made suggestions on how to extend the system: P5 wanted to add a printer to the tabletop, so that digital objects can be printed ad hoc and then used as physical objects. P4 wanted a semantic based visibility control which hides all digital content not relevant to the physical document currently in the focus area.

IMPLICATIONS ON HYBRID STACKING
Based on the results of our study, we derived a set of design implications for systems supporting hybrid stacks.

Digital or Physical Oriented Interaction?
While we initially thought that relying on the possibilities of digital documents to augment hybrid stacking (e.g. providing the *copy on drag out* behavior) would be beneficial for both, digital and physical, documents, our study clearly showed that users expect and want the hybrid stack to behave more like a physical stack. Nevertheless, the digitally inspired techniques were rated as useful in special situations. As a result, techniques providing non-physical behavior of objects within the stack should be made accessible through special gestures. The standard touch interaction gestures (e.g. one finger drag) should lead to behavior known from the physical world.

Visualizing the Stack
Visualizing a hybrid stack is a challenging task, as the physical part has a physical height, while the digital part does not. Ideally, one would be able to visualize additional sheets of paper at the location the digital documents are placed within the stack. Currently, this is not possible, but one can chose visualization techniques showing some height clues to the user. Taking our register-metaphor, it could be extended by displaying documents between the registers. The registers would then be irregularly spaced according to their thickness, giving more clues about their position compared to the current even spacing independent of the number of documents.

Accessing the Stack

Accessing or browsing a stack is one of the more tedious tasks, hence digital augmentation is well received there. Depending on the use-case, access to either the whole stack (like in our StackPath technique) or a subset (like our registers) is desired by users. Systems should therefore be able to accommodate both styles of access. Based on the general user feedback, it could even be desirable to expand the concept to context sensitive techniques, like automatically highlighting stacked documents based on the document the user currently works on (e.g. is within his working area).

CONCLUSION AND OUTLOOK

In this paper, we presented a first study on hybrid stacking for interactive tabletops which has shown a great potential for hybrid stacking. Based on the results, we can answer our initial research questions as follows:

Do users employ their natural practices of stacking in a true hybrid environment?

Based on the study, the answer is definitely yes. The AttrakDiff results and the users' reactions clearly show that hybrid stacking is well received and users like to use it.

How do they perceive the concept of hybrid stacking and how do they perform?

We initially thought that users might have problems with the fact that digital content can now be between two physical objects and not only on a specific digital surface. However, the study has shown that users do not have any issues with this and that they casually use hybrid stacks without much (mental and general) effort.

The feedback indicated some design issues with the current techniques offered by StackTop, which can be easily solved (e.g. changing the behavior to a more physical-like one).

FROM HYBRID TO SMART STACKING

While aimed at hybrid stacks on digital tabletops, the concepts of StackTop directly apply to purely physical stacks as well and can easily be expanded to other means of organization as well. Using a high-resolution projection system, it is even possible to implement the concepts on conventional office desks if accepting the drawbacks of projection (e.g. occlusion by the user), which is to some extent mitigated by the use of an active tabletop display. This allows for instance to augment conventional stacks or folders to become smart stacks (or folders). Leveraging the StackTop concept to build smart physical knowledge-work environments can be accompanied by expanding the current browsing and accessing techniques provided by StackTop with additional search facilities and context aware functionality. By adding context awareness, the smart stacks are not only passive interactive objects where all actions are user-driven, but can rather become active actors in the work environment. For instance, the
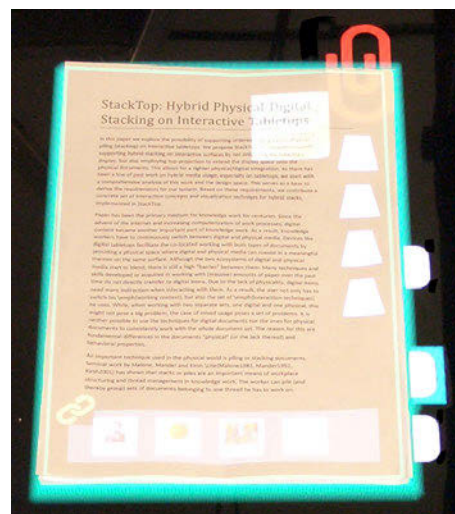

Figure 12: Highlighting of a document within the stack; the stack as well as the register containing the document are marked with an outline

system can detect the current task carried out by the user and then highlight relevant documents, e.g. based on their content or on which documents the user used last time working on a similar or even the same task. In order to do so, the system would have to track the documents and their content to provide the context-awareness. Therefore, it is sensible to use this information to provide advanced search facilities as well to make the whole work environment (full-text) searchable. Figure 12 shows how the highlighting of a document within a stack could look like.

ACKNOWLEDGEMENT

REFERENCES

1. Anand Agarawala and Ravin Balakrishnan. 2006. Keepin' It Real: Pushing the Desktop Metaphor with Physics, Piles and the Pen. In *Proceedings of the SIGCHI Conference on Human Factors in Computing Systems (CHI '06)*. ACM, New York, NY, USA, 1283–1292. DOI:
http://dx.doi.org/10.1145/1124772.1124965

2. Dan Bauer, Pierre Fastrez, and Jim Hollan. 2004. Computationally-Enriched 'Piles' for Managing Digital Photo Collections. In *Proceedings of the 2004 IEEE Symposium on Visual Languages - Human Centric Computing (VLHCC '04)*. IEEE Computer Society, Washington, DC, USA, 193–195. DOI:http://dx.doi.org/10.1109/VLHCC.2004.13

3. Kensaku Fujii, Jun Shimamura, Kenichi Arakawa, and Tomohiko Arikawa. 2003. Tangible Search for Stacked Objects. In *CHI '03 Extended Abstracts on Human Factors in Computing Systems (CHI EA '03)*. ACM, New York, NY, USA, 848–849. DOI:
http://dx.doi.org/10.1145/765891.766029

4. Marc Hassenzahl, Michael Burmester, and Franz Koller. 2003. AttrakDiff: Ein Fragebogen zur Messung wahrgenommener hedonischer und pragmatischer Qualität. In *Mensch &*

Computer 2003: Interaktion in Bewegung, G. Szwillus and J. Ziegler (Eds.). B. G. Teubner, Stuttgart, 187–196.

5. Daisuke Iwai and Kosuke Sato. 2006. Limpid desk: see-through access to disorderly desktop in projection-based mixed reality. In *Proceedings of the ACM symposium on Virtual reality software and technology (VRST '06)*. ACM, New York, NY, USA, 112–115. DOI: `http://dx.doi.org/10.1145/1180495.1180519`

6. Mikkel Rønne Jakobsen and Kasper Hornbæk. 2010. Piles, Tabs and Overlaps in Navigation Among Documents. In *Proceedings of the 6th Nordic Conference on Human-Computer Interaction: Extending Boundaries (NordiCHI '10)*. ACM, New York, NY, USA, 246–255. DOI: `http://dx.doi.org/10.1145/1868914.1868945`

7. Mohammadreza Khalilbeigi, Jürgen Steimle, and Max Mühlhäuser. 2010. Interaction techniques for hybrid piles of documents on interactive tabletops. In *CHI '10 Extended Abstracts on Human Factors in Computing Systems (CHI EA '10)*. ACM, New York, NY, USA, 3943–3948. DOI: `http://dx.doi.org/10.1145/1753846.1754083`

8. David Kirsh. 2001. The Context of Work. *Hum.-Comput. Interact.* 16, 2 (Dec. 2001), 305–322. DOI: `http://dx.doi.org/10.1207/S15327051HCI16234_12`

9. H. Koike, Y. Sato, and Y. Kobayashi. 2001. Integrating paper and digital information on EnhancedDesk: a method for realtime finger tracking on an augmented desk system. *ACM Trans. Comput.-Hum. Interact.* 8, 4 (Dec. 2001), 307–322. DOI: `http://dx.doi.org/10.1145/504704.504706`

10. Chunyuan Liao, Hao Tang, Qiong Liu, Patrick Chiu, and Francine Chen. 2010. FACT: fine-grained cross-media interaction with documents via a portable hybrid paper-laptop interface. In *Proceedings of the international conference on Multimedia (MM '10)*. ACM, New York, NY, USA, 361–370. DOI:`http://dx.doi.org/10.1145/1873951.1874001`

11. Thomas W. Malone. 1983. How Do People Organize Their Desks?: Implications for the Design of Office Information Systems. *ACM Trans. Inf. Syst.* 1, 1 (Jan. 1983), 99–112. DOI: `http://dx.doi.org/10.1145/357423.357430`

12. Richard Mander, Gitta Salomon, and Yin Yin Wong. 1992. A "Pile" Metaphor for Supporting Casual Organization of Information. In *Proceedings of the SIGCHI Conference on Human Factors in Computing Systems (CHI '92)*. ACM, New York, NY, USA, 627–634. DOI: `http://dx.doi.org/10.1145/142750.143055`

13. H. Mitsuhara, Y. Yano, and T. Moriyama. 2010. Paper-top interface for supporting note-taking and its preliminary experiment. In *Systems Man and Cybernetics (SMC), 2010 IEEE International Conference on*. IEEE Computer Society, Washington, DC, USA, 3456–3462. DOI: `http://dx.doi.org/10.1109/ICSMC.2010.5642448`

14. Jan Riemann, Mohammadreza Khalilbeigi, Niloofar Dezfuli, and Max Mühlhäuser. 2015. StackTop: Hybrid Physical-Digital Stacking on Interactive Tabletops. In *Proceedings of the 33rd Annual ACM Conference Extended Abstracts on Human Factors in Computing Systems (CHI EA '15)*. ACM, New York, NY, USA, 1127–1132. DOI: `http://dx.doi.org/10.1145/2702613.2732742`

15. Stacey D. Scott, M. Sheelagh T. Carpendale, and Stefan Habelski. 2005. Storage Bins: Mobile Storage for Collaborative Tabletop Displays. *IEEE Comput. Graph. Appl.* 25, 4 (July 2005), 58–65. DOI:`http://dx.doi.org/10.1109/MCG.2005.86`

16. Jürgen Steimle, Mohammadreza Khalilbeigi, Max Mühlhäuser, and James D. Hollan. 2010. Physical and digital media usage patterns on interactive tabletop surfaces. In *ACM International Conference on Interactive Tabletops and Surfaces (ITS '10)*. ACM, New York, NY, USA, 167–176. DOI: `http://dx.doi.org/10.1145/1936652.1936685`

17. Pierre Wellner. 1993. Interacting with Paper on the DigitalDesk. *Commun. ACM* 36, 7 (July 1993), 87–96. DOI: `http://dx.doi.org/10.1145/159544.159630`