Towards Document Engineering on Pen and Touch-Operated Interactive Tabletops

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ABSTRACT
Touch interfaces have now become mainstream thanks to modern smartphones and tablets. However, there are still very few "productivity" applications, i.e. tools that support mundane but essential work, especially for large interactive surfaces such as digital tabletops. This work aims to partly fill the relative void in the area of document engineering by investigating what kind of intuitive and efficient tools can be provided to support the manipulation of documents on a digital workdesk, in particular the creation and editing of documents. The fundamental interaction model relies on bimanual pen and multitouch input, which was recently introduced to tabletops and enables richer interaction possibilities. The goal is ultimately to provide useful and highly accessible UIs for document-centric applications, whose design principles will hopefully pave the way from DTP towards DTTP (Digital Tabletop Publishing).

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INTRODUCTION
The last years have seen a considerable increase in interest for touch-based user interfaces. While the popularity of tactile devices has largely been driven by smartphones, tablets and ebook readers, in the HCI research community, researchers have considered a wider variety of interactive surfaces, ranging from small form factor devices to very large surfaces (and combinations thereof). Among the considered systems, digital interactive tabletops form a prominent category. Throughout the years, a number of experimental prototypes have been built to create new interaction experiences on augmented tables and horizontal surfaces.

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It has taken some time for commercial vendors to see the potential of such machines so that it is only recently that mass-produced systems supported by robust SDKs, such as Microsoft PixelSense (formerly Microsoft Surface)[1], have become available. Now that researchers have such equipment at their disposal, they are able to focus their attention on software functionality and practical applications. That is not to say that nothing has been done on that front in the past two decades in parallel with those hardware experiments. There have indeed also been considerable efforts in producing dedicated solutions for tabletop platforms (accompanied by a wealth of studies), especially in collaborative scenarios, where the digital table functions as a shared workspace for multiple users [14].

One domain that arguably lends itself well to tabletop interaction is document engineering, i.e. the processes and tools that govern the creation, management and maintenance of documents. People naturally engage with physical documents using pen and paper so that one can easily see the appeal of an apparatus that mimics those properties, while at the same time also endowing users with the power of digital tools (searching, editing aids, storage etc.). The large, fixed, interactive working surfaces that digital tabletops afford make them compelling systems compared to tablets, e-slates and other mobile devices, which are probably more suitable for reviewing and limited editing work. In particular, tabletop interfaces that can be operated by simultaneous and differentiated pen and touch input promise many advantages, as they combine the precision of the pen with the comfort and intuitiveness of direct touch input, while also bringing further benefits and richer interaction possibilities when the two modalities are used together [9].

The vision of the virtual workdesk as part of the office of the future, where knowledge workers manipulate digital content on a variety of interactive surfaces is not new. Yet, surprisingly, there seems to have been little exploration done beyond workspace environment considerations and proof-of-concept demonstrations for specific scenarios such as meetings and basic collaborative work (collocated and remote). Critically, there is still a dearth of real-world applications that demonstrate substantial productivity

[1] http://www.pixelsense.com

benefits in creative document tasks. The field is therefore very much wide open. Considering this observation, it makes sense to engage research efforts in this area and lay the groundwork for what could possibly become the basis of document creation and editing on digital desks in offices of the future.

PREVIOUS WORK

Perhaps the most famous system that pioneered new workflows integrating analogue and digital documents on an augmented workdesk is Wellner's DigitalDesk [16]. This seminal work inspired researchers to develop further hybrid solutions [1, 5, 17] and enhancements to traditional workspaces [11, 2] to increase the user's efficiency when working with documents, while sacrificing as little as possible in intuitiveness and user-friendliness for the interface. Another popular avenue that was explored by many researchers is that of augmented paper that adds interactive capabilities to regular paper documents for linking, annotating and other manipulations [8]. The lack of immediate feedback via the medium, however, limits the scope of applications' interactivity and functionality. With technological advances and the advent of tablets, ebook readers and e-paper, in situ document interactivity became possible (although current paper-like devices are still far from matching all affordances and properties of physical paper), which led to a number of systems based on those devices [15,18].

As mentioned above, there have been surprisingly few document applications developed for interactive tabletops that extensively focus on the creating and editing aspect. This might change as hardware becomes more readily available (and affordable) and productivity applications showcasing the strengths of those digitally enhanced working environments are produced A promising interaction paradigm that builds on the paper and workdesk metaphor is multitouch tabletops that can also simultaneously be operated with a digital pen. The advantages of having both modalities available together to manipulate content on the tabletop surface have been investigated by Brandl et al. [3] and more extensively by Hinckley et al [9]. The authors show, notably, that coordinated asymmetric gestures can produce a synergistic effect that contributes to increasing task efficiency. The benefits of this interaction model have materialised in a few interesting applications, such as a diagram editor [6] and a maths program [19]. Last but not least, a commercial pen and touch system came onto the market this year, with support for pressure-sensitivity for the stylus and palm rejection[2].

RESEARCH OBJECTIVES

The main objective of the proposed research is to explore and leverage the potential of interactive tabletop systems for the efficient and intuitive execution of document engineering tasks, with a particular focus on document editing. Due to the wide variety of document types, engineering processes and contexts where documents are utilised, the work will have to target a subset of these categories, for example office documents. In fact, it is also an aim of the project to investigate which kinds of documents and use-case scenarios are more suitable for a tabletop compared to authoring on a desktop computer in a traditional WIMP[3]-style environment. For instance, forms, plans and CAD designs, which are documents that have strongly grid-based layouts and little text, seem to be ideal candidates for pen-based design. The same is also likely to be true for documents that include many reusable components such as logos, images and figures (e.g. presentations, posters) because these elements can be seamlessly retrieved and inserted in template placeholders using hand gestures or the stylus [12]. Conversely, text-intensive documents might prove less appropriate for such platforms, as text is likely less efficiently input using a soft keyboard or the pen compared to typing with a physical keyboard, although this has not yet been indisputably demonstrated on large tabletop surfaces [10].

While ideally the tabletop should provide a self-sufficient environment for the required document engineering tasks, in practice, legitimate needs for integration with existing document workflows and legacy equipment are bound to arise. For example, a document created on the tabletop by a designer might require additional editing on a desktop computer before it is sent for further processing to a document management server. The document might even be returned to the designer for modifications at some point in the processing chain. This scenario raises a number of issues that must be taken into account in the design of the tabletop application. The creation process here has to be considered in a broader context, as part of the whole document lifecycle, which can conceivably be complex and involve multiple parties. Integration and coordination requirements may not only affect the document formats and I/O channels that need to be supported by the application but also the design of the user interface itself, for example if versioning information and editing history need to be visualised.

WORK SO FAR

The main driving effort adopted for this research roughly follows an iterative, trial-and-error process, based on a bottom-up approach that favours exploration and liberal investigation of interesting issues that may emerge within the scope of the general goals outlined above.

Active Reading on Pen&Touch Tabletop

In an initial step, a first prototype supporting the task of active reading was developed based on results from prior work and intuition [13]. The aim was to gain a first footing with a relatively limited yet practically useful document application and discover critical usability issues arising from hardware and design choices. One of the goals, in

[2] http://www.perceptivepixel.com/products/active-stylus

[3] http://en.wikipedia.org/wiki/WIMP_(computing)

particular, was to examine if the advantages of paper interaction could be effectively combined with certain facilities people have come to expect from computer systems, such as rapid navigation and searching, without the disadvantages of each medium. Thus, the proposed system relies on a loose paper metaphor, where the document is presented as a bound volume on the interface, on which the user can perform annotations with the pen (Figure 1).

Figure 1: The active reading application running on a DiamondTouch tabletop [4] augmented with Anoto technology[4]

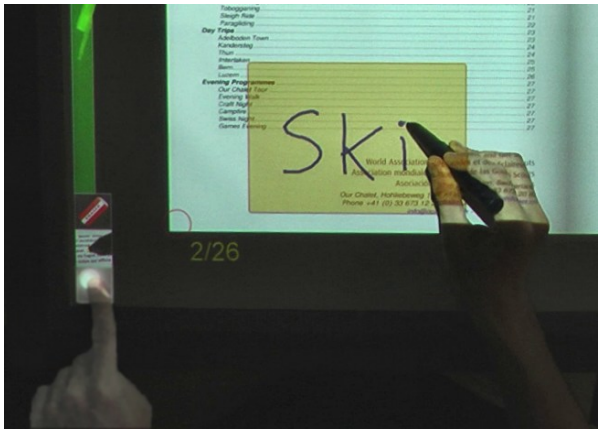

Figure 2: Handwriting a search term with the DH with search function activated by the NDH

The interface includes a toolbar via which various functions can be activated. Following the division of labour principle [7, 9], the dominant hand (DH) holding the pen is mainly used for inking (i.e. fine motor action), whereas the non-dominant hand (NDH) executes coarser manipulations such as panning, zooming and page-turning. The two hands can be combined to trigger actions according to an "activate and pen" model, where the NDH activates a trigger area on the surface (such as a toolbar function) and the DH with the pen inputs the parameters of said action. This is for instance how the search functions can be performed: the user taps on the appropriate function icon in the toolbar with his/her NDH and writes a keyword anywhere on the interface. A handwriting algorithm then interprets the entered text and a query is launched on the document based on the recognised terms (Figure 2).

Keywords can also be selected directly in the document in a similar way by activating the relevant toolbar function and circling words that appear on the open page(s) of the document. Furthermore, annotations that need be deleted can be removed easily by tapping the eraser command icon and striking through the desired annotations. This bimanual combination is quick and reliable, as it does not rely on any error-prone gestures, such as squiggles or cross-outs.

The application also included bimanual touch gestures to flip multiple pages with two fingers (Figure 3) and to trigger an overview mode displaying a flat layout with all pages of the document using a "chop and spread" gesture.

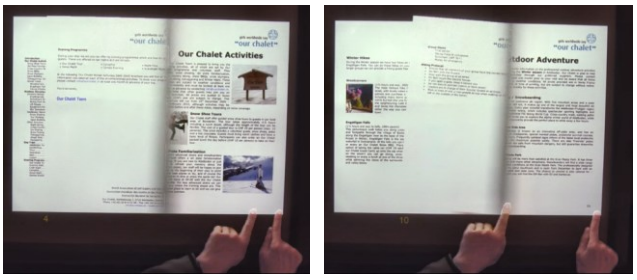

Figure 3: Forward multiple page flip: the right index activates the right corner of a page and the left index moves laterally to flick through the pages

The user evaluation that was conducted and which compared the tabletop application to paper and a regular PC running Adobe Acrobat delivered interesting results and insights about the taken approach. Most importantly, the study suggested that the advantages of paper and the computer could indeed be effectively combined in a single interactive system, albeit with a few caveats. For instance, one lesson was that the paper metaphor should not be overly pushed for the sake of mimicking an existing behaviour in the physical world. Practical concerns also dictate design choices and should not be ignored, even in interfaces that aim to remain close to a natural environment. Furthermore, the experiments revealed a number of important hardware issues that affect the users' experience when handling text documents on a tabletop screen, most significantly display and sensing resolutions.

The reader is referred to the full paper describing the system and the evaluation for further details [13].

CURRENT AND FUTURE WORK

Efforts are currently focused on the main component of the project, which tackles the actual task of document creation and editing. Other than providing adequate tools to compose single documents, the plan also foresees an extension of the scope to multiple documents that can share common elements in order to facilitate re-use (considering a document is not always composed from scratch on its

[4] http://www.anoto.com

own). The application will therefore have to provide an underlying infrastructure to efficiently store and manage these document elements, which will be served by appropriate UI functionality to transfer and share those elements between documents. A document model with two-way links between elements and documents that contain them (one element may be shared by several documents) not only brings more flexibility and lighter memory footprints (especially if the re-use factor is high) but also enables element-based searching, i.e. the retrieval of documents that use a particular version of a query element, or even similar elements if a content-based comparison module is available.

Editing tools will have to make clever use of the pen and multitouch capabilities of the tabletop system. Design choices will have to be made to determine how editing functionality is accessed and operations executed. What is done with touch, with the pen, with both, and how? Should the editor rely on visible widgets that continuously expose the operational environment on the interface? Or should the application tools and commands, on the contrary, remain unobtrusive and be triggered by gestures (is it in fact possible to achieve this in this context?) The crucial question of text input that was touched upon further above also needs to be addressed. Is text best entered using the pen and handwriting? (In that case, how are misrecognised words handled?) A soft keyboard with or without Swype-style mechanisms[5]? Speech? Those questions and others will constitute the main drive for the design and development of the prototype.

CONCLUSION

Interactive tabletops are promising working platforms for productivity and creative document engineering tasks. In particular, the pen and touch input paradigm shows great potential for particular scenarios and document types. As the digital desk is poised to gain wider public acceptance and perhaps soon enter the workplace, there is a need to support this breakthrough with the appropriate productivity tools that the knowledge worker requires. There is a vast expanse of uncharted waters ahead and hence there is much work to be done.

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[5] http://en.wikipedia.org/wiki/Swype