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Key to success: Using Zoomable UIs on Interactive Surfaces in Real-World Corporate Scenarios

Die Verwendung von ZUIs auf Interaktiven Oberflächen als Schlüssel zum Erfolg in realen Unternehmens-anwendungen

Multi-touch surfaces_zoomable user interfaces_zooming_panning_tabletop_distributed-display environment

Zusammenfassung. Zoombare Benutzerschnittstellen (ZUIs) sind in der Mensch-Computer Interaktion eine gereifte Idee. Dennoch konnte sich bislang kein "reines" ZUI als Oberflächenkonzept durchsetzen. Was sich aber beobachten lässt, ist die Tatsache, dass heutige Tablets und Touch Geräte im allgemeinen sehr viele Facetten von ZUIs aufgreifen und integrieren. In diesem Artikel präsentieren wir mit smartPerform ein zoombares Präsentationstoolkit, welches basierend auf den Forschungsarbeiten an der Universität Konstanz im Zusammenhang mit ZUIs kommerziell entwickelt wurde. Anhand von "best-practice" Beispielen unserer Kunden zeigen wir das Potential von ZUIs im Zusammenhang mit interaktiven Oberflächen auf, insbesondere auch im Kontext von Distributed-Display Environments.

Summary. Zoomable User Interfaces (ZUIs) are a well-established idea for the design of human-computer interfaces. While the vision of a "true" ZUI in its stricter sense has not become reality yet, today's tablets and touch devices feature many facets of zoomable user interfaces. In this article, we will present smartPerform, a zoomable presentation toolkit which has been commercially developed based on academic research on ZUIs at the University of Konstanz. By illustrating best practices from our customers, we will show that ZUIs are a particularly promising in combination with interactive surfaces and distributed display environments.

1. Introduction

Based on our experiences, we believe that zoomable user interfaces (or ZUIs) provide the key to success for the design of interactive surfaces and their applications. This is specifically true when we go beyond the typical "photo-browser" application towards real-world corporate scenarios. The basic idea of zoomable user interfaces can be summarized as organizing the data objects of a virtual information space in visual 2D space and scale and using animated zooming and panning as primary means of navigation of and interaction with this information space. The history of ZUIs dates back to the early beginnings of graphical user interfaces. The Spatial Data Management System (SDMS) was probably the first interface that incorporated zooming as the main interaction metaphor but needed specialized computer and video hardware that filled an entire room (Donelson 1978). Almost 15 years later, the first PC-based ZUI system was introduced by Perlin & Fox, who also formulated the key assumption that has driven ZUIs in research and practice since then: "navigation in information spaces is best supported by tapping in our natural spatial and geographical ways of thinking" (Perlin & Fox 1993). This assumption specifies one of the main supposed advantages of ZUIs – that they would make better use of our spatial orientation, navigation skills and memory. By this, ZUIs also address a core problem of desktop human-computer interaction, namely that we only have a rather small window (the screen) to see (and eventually interact with) the underlying information space. Contrary, the traditional desktop metaphor clutters information across multiple applications and in abstract hierarchies, such as the file system – resulting in "mazelike" interfaces, as Raskin puts it (Raskin 2000) with "a great cognitive load for navigating, finding information, or managing windows" (Jetter et al. 2012).

Bederson, as a researcher who devoted many years to the design of ZUIs, recently summarized the field's effort to establish zoomable user interfaces in real-world systems and discussed why the overall "vision of zooming as a basic information organizational principle has not happened" (Bederson 2011) – at least in terms of a large user base or

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commercial success. He identified three main advantages of ZUIs: First, ZUIs are engaging in terms of their animation being "attention grabbing", allowing the audience to "process the visual flow preconsciously". Second, they are visually rich as they allow the freedom to arrange information objects both in space and scale. Third, they "offer the lure of simplicity" by providing an implicit overview of the information space and, allowing the human's visual memory to be used to comprehend and memorize "where everything is". However, Buering (2007) and Bederson (2011) also discuss some of the main limitations of ZUIs: First, ZUIs may offer too much freedom in navigation, leading to "desert fog" issues (Jul & Furnas 1998). Even if this specific problem is avoided (e.g. by restricting navigation to documents only), ZUIs can still be difficult to comprehend and orientate in. In particular when they contain thousands of documents in multiple levels, users simply might get lost in zoom space. Second, no agreement has been reached about how to interact in ZUIs. Still lacking the commercial killer application that establishes a de-facto standard, more or less every ZUI has an individual interaction style, e.g. using double clicks to zoom in, zooming out via button or via a click on a "zoom out area".

From our experience, Bederson is absolutely right about the fact that the "vision of zooming as a basic information organizational principle has not happened" (Bederson 2011). Nonetheless commercial systems such as PREZI (www.prezi.com) and ICT smartPerform (www.smartperform.de) are examples of individual applications with a growing user base. We agree with Bederson that the fundamental change to ZUIs did not happen – instead we have seen a gradual implementation of ZUI concepts to a degree that one could argue that the idea of ZUIs has in fact already materialized. Apart from individual applications, Jetter et al. (2012) argue for the use of ZUIs not for replacing traditional desktop user interfaces, but for creating "Post-WIMP Distributed User Interfaces" that use zooming and organization in space and scale for collaboratively accessing and manipulating objects with several co-located interactive surfaces in physical interactive spaces. Based on our experiences that we have gathered in real-world commercial projects this perspective for the future of ZUIs is a particular promising one.

This paper contributes to the experiences with interactive surfaces on several levels. First, we will briefly describe the research foundations of ZOIL as outlined in Jetter et al. (2012) and Jetter (2013). Second, we will illustrate how the ZOIL design principles have been manifested in ICT smartPerform – a ZUI platform for multi-touch and multi-display interactive spaces, that has been developed for three years now and has since reached a considerable level of commercial success as a "live communication platform" (www.smartperform.de), with revenues reaching seven-digit numbers this year. Third, we will discuss the application areas and use cases for interactive surfaces today, based on our experiences from ICT AG as well as the still complex interweaving of hardware and software. We will address the challenges of such projects and discuss the outlook for interactive surfaces and spaces in particular. Finally, we would like to point out that this is an industry perspective on interactive surfaces that showcases how ideas from research can be transferred to successful products. This paper won't provide new insights from empirical research but rather give a perspective and idea on "what works from practical experience". It is also a very personal article from the authors, who have devoted many years on these topics – therefore we found it appropriate to include anecdotal parts here as well.

2. From ZOIL to smartPerform

In Bederson's article "the promise of zoomable user interfaces" the author describes how he got fascinated with ZUIs during his late work on his PhD in 1992 while working in the same lab as Perlin. He then started to focus many years of research on this topic. The authors of this paper experienced a similar „obsession" about 12 years later in 2004. However, not Perlin & Fox nor Bederson led to this fascination but a simple Adobe Flash demo of Raskin's Zoomworld (Raskin 2000) that demonstrated how information objects could be accessed and managed in a visually stunning, l comprehensible and seemingly logical way – simply by zooming and panning through space (see figure 1).

As a consequence, the idea of ZOIL was born, a Zoomable Object-oriented Information Landscape that initially shared many similarities to Perlin & Fox' Pad (Perlin & Fox 1993) and Bederson's Pad++ (Bederson et al. 1996). While first being primarily aimed at desktop workstations in the sense of information seeking systems, personal information management, and information visualization (Gerken 2009), we realized the true potential of ZUIs when we applied them to the design of interactive multi-display environments in combination with novel interaction modalities such as multi-touch. While traditional WIMP interfaces have been and still are very difficult to adapt to (multi-) touch (e.g. in terms of size of controls and navigation structure through menu-driven designs), zoomable user interfaces were not only easier to transfer but they also

Figure 1: Raskin's Zoomworld showcases a complex information space that can be navigated solely by zooming and panning (Raskin 2000)

made it possible to define a novel set of design guidelines for such environments in which tradtional designs of the Web and GUI failed (Jetter et al. 2012). Bederson (Bederson 2011) acknowledges that zooming on touch screens has become a very popular and requested functionality and "pinching" in order to zoom has become the de-facto standard. However, this is not just a matter of mobile devices and small screens – from the experience we gathered in real-world projects, users expect this kind of interaction on any (touch-) screen they can find, no matter the size. Touching and zooming seem to be a natural combinationand creating a multi-touch interface without zooming severely collides with users' expectations and "touch systems consistency".

2.1 The ZOIL Paradigm

Jetter et al. (2012) define the ZOIL paradigm, whose design principles we briefly summarize here. At ZOIL's heart is a visual workspace called the information landscape. This workspace allows organizing information objects in space and scale and can be navigated with different input modalities mainly through zooming and panning (see figure 2).

The first ZOIL design principle argues for the use of an object-oriented user interface (OOUI) for direct manipulation – thereby leaving the application-centric world of GUIs and their many administrative controls behind and making the actual content the first-level citizen of the user interface. The idea is that users stop worrying about their applications and the problems with different interaction styles and procedures. Instead, the interface "focuses the users on objects – the "things" people use to accomplish their work" (Roberts et al. 1998). In a ZOIL user interface the objects, their attributes, their attached functionality and their mutual relations are integrated into an object model that is visualized in the information landscape, so that the ZOIL application is actually a kind of zoomable browser for the object model. All data types and all kind of functionality is integrated into a single coherent workspace. Jetter et al (2012) argue that OOUIs have many benefits for post-WIMP interaction because they facilitate the modular distribution of content and functionality to different devices with different input modalities. Instead of creating different device-specific applications with rigid interaction sequences and workflows, OOUIs enable a flexible structure by object that supports many different working and collaboration styles.

The second design principle argues for the use of ZUIs with semantic zooming (Perlin & Fox 1993). Semantic zooming extends the zooming concept which we already discussed in this article in such a way, "that the growth of an object in display space is used not just to render the same object in a higher resolution but also to reveal different and more content and functionality" (Jetter et al. 2012). This allows the integration of different content layers in zoom space and avoids the need for pop-up windows or similar techniques. In the context of OOUI, ZUIs furthermore help to focus on information objects instead of abstract navigation through menu driven interfaces ("the content is the interface"). Visually and cognitively, the content becomes the object of interest and navigation.

The third design principle argues for the integration of visualization tools to facilitate analytical views of and search in the information space, thereby overcoming some of the limitations of ZUIs, such as the need for intense navigation between items when comparing them (see figure 3).

Figure 3: Different ZOIL visualization tools that allow different perspectives on the same set of information objects (Figure adapted from Jetter et al. 2012).

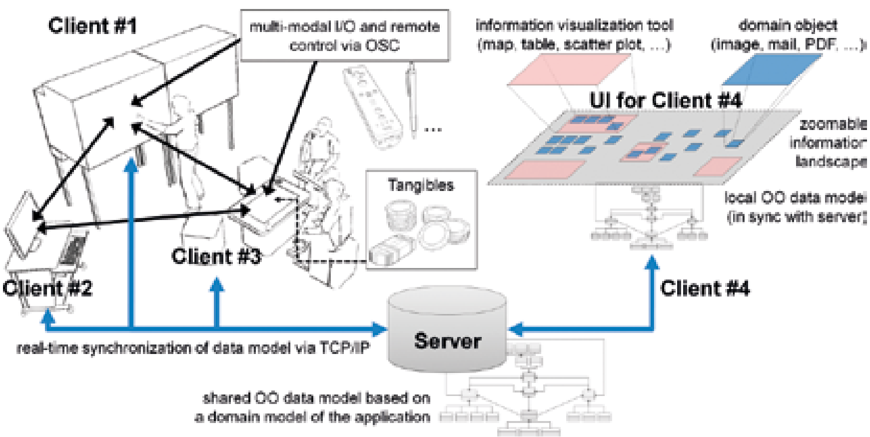

Figure 2: The ZOIL architecture, showing the distributed object model and how the zoomable information landscape is distributed among different devices (Figure adapted from Jetter et al. 2012).

The fourth design principle asks for enough "space to think", i.e., enabling users to arrange and annotate their information in space and scale. This is particularly important in multi-display environments, where positions in physical space (e.g. a display or device) and in virtual space (e.g. positions or clusters of items in the information landscape) carry different meanings and play different roles. In particular, this is the case for the spatial layout of items in ZUIs that conveys implicit contextual information about the relation and importance of items and is used by both designers and users extensively.

The fifth design principle is concerned with the ability to distribute a user interface across devices. ZOIL uses a "camera-based" approach, where the underlying object-model is shared through a database and each device renders a section of this shared information landscape acts as a window with which users can independently navigate and manipulate the shared content.

The sixth and last design principle addresses the need to specifically support multi-user collaboration. As ZOIL is meant to support multi-display interactive spaces, using these environments is typically a collaborative activity, requiring users to be able to work together or in individual roles. Important issues here are techniques to allow group awareness, a smooth transition between loosely-coupled and tightly-coupled parallel work, and the underlying support in both hardware and software for such parallel interaction styles.

Within our research environment at the University of Konstanz, ZOIL has been applied and demonstrated its potential within numerous scenarios of use from different domains, ranging from creativity support tools (Geyer et al 2011) to information seeking systems for library or product search (Jetter et al. 2011). Furthermore, it has been applied as a presentation and discussion space for nanophotonics researchers in the DeskPiles project (see figure 4). This implementation was especially inspirational for the commercial transfer of ZOIL to ICT smartPerform, which we will discuss in the following section.

Figure 5: New content can be integrated into smartPerform by Drag&Drop from the Windows Explorer. It can then be freely arranged and scaled as well as organized in hierarchical layers which we call "containers".

2.2 ICT smartPerform

ICT AG (http://www.ict.de) is a full service provider for IT and media solutions in the context of trade fairs, show rooms, meeting rooms, and museums. ICT smartPerform was created as a platform and presentation software for large multi-touch screens and interactive surfaces in general. While the ZOIL paradigm may be applied to any kind of application domain, ICT smartPerform focuses specifically on presentation situations, thereby serving as a "live communication platform". By platform we mean that smartPerform serves a role similar to Microsoft Powerpoint for Desktop presentations, allowing customers to create their own presentations and applications based on our toolkit by visual and graphical configuration in a "what you see is what you get" manner. Like ZOIL, it is created with Microsoft .Net / Windows Presentation Foundation (WPF) and runs on Windows-based devices starting with Windows Vista and above. To illustrate the system, we will discuss it along the lines of the ZOIL design principles.

Principle 1: Object-oriented User Interface

Following the principle of object- instead of application-orientation, the object-oriented user interface of smartPerform allows the creation of a presentation environment, where both, the creator and the end-user do not have to care about different file formats and applications. smartPerform provides users with a large zoomable canvas as a kind of visual meta-layer above the file system that allows them to integrate all kind of information objects by dragging & dropping files into the application window from the Windows Explorer (see figure 5). Unlike in an application-oriented environment, users can then manage every file and therefore every type of object in a uniform way. Thus, smartPerform serves as a portal that allows a seamless navigation between and presentation of different content types, while providing ways for graphically customizing these transitions so that they appear smooth and seemingly natural.

More concretely, users can customize the appearance with custom-preview images and predefined styles that define how the content is visualized (e.g. as a Coverflow visualization). Upon zooming in, the according object viewer is integrated into the smartPerform environment, providing a consistent user experience, despite the integration of different native applications such as Microsoft Powerpoint, Adobe Acrobat or MS Internet Explorer (see figure 6). Besides these more generic attributes, that are identical for all information objects, every information object still has application-specific attributes attached, e.g.

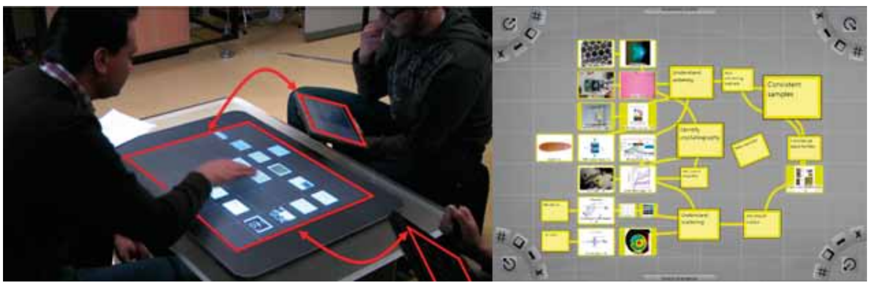

Figure 4: DeskPiles prototype. The basic idea was to create a multi-display discussion space with possibilities for easy data integration and annotation – two principles that have been adapted in smartPerform right from the beginning (Figure adapted from Jetter et al. 2012).

Figure 6: smartPerform can integrate various file formats and applications, such as images, videos, MS Powerpoint or Adobe PDF – all files are treated as information objects with individual object viewer properties.

enabling to select pre-defined preview images for PDF documents or setting up a certain style template. Information objects can also be organized in hierarchies of "container" objects. Containers are information objects on their own right that are treated identical to files – their object viewer simply displays the containing content in a certain way.

Principle 2: Zoomable User Interface

smartPerform follows the principal approach of ZUIs by relying on zooming and panning as the primary navigation and interaction styles. As Bederson notes, the engaging style of ZUIs is certainly adequate for presentation environments – as may already explain the relative high number of presentation solutions that have been explored or commercialized, such as Prezi or pptPlex (see Bederson 2011 for a list). In combination with the OOUI, a ZUI provides the presenter the possibility to switch between different contents without needing to switch applications over a third party interface (e.g. the Windows desktop). Zooming allows these transitions to be smooth and be part of the story telling (see figure 7).

While Bederson is right, that if and to which extent zooming might help people to understand and memorize the content is not validated empirically, we have received very positive feedback on this presentation style. Especially, the possibility to escape the linearity of standard presentations and being able to react upon the audience specific information needs and interests, is a tremendous advantage of an interactive ZUI environment such as smartPerform – no matter whether it is used to present a talk or as an interactive explorative information system. However, it is important to balance the information hierarchy breadth vs. depths in favor of breadths. In our experience, more than four levels in depth lead to "lost in zoom space" problems, even though we constantly display the "path" or depth hierarchy. Nevertheless, smartPerform can successfully host a huge number of documents. For example, Siemens Healthcare has more than a thousand Powerpoint files integrated and several hundreds more of images, flash files, etc. (>40 GB of data) and are able to navigate this information space very efficiently.

Principle 3: Integration of visualizations

While smartPerform hasn't integrated any kind of "typical" visualization tools, it clearly separates the content view from the content itself. Thereby, we are able to visualize the same content differently by selecting pre-defined style sets. For example, the images in a container may be visualized in a spatial layout, typical for a ZUI, or, as a cover-flow visualization for an engaging swiping interaction (see figure 8).

The technical implementation of smartPerform was designed in a way to integrate this design principle more prominently in the future with more advanced visualizations. This again follows an object-oriented approach, as users can define the appearance of their information objects independent of the content and the application itself. It is also a concept that scales very well, as these visualizations are simply functionality attached to certain objects and not "new applications".

Principle 4: Space to think

smartPerform allows users to create their own zoomable user interface and arrange content in a spatial layout – not just random but with semantic meaning to the relative positions of information objects. While not mandatory, space thereby can be encoded with information that may allow users to access and relate the content much easier. From our experience, a zoomable UI will always help using "white space" more systematically and without the regret to waste space.

Figure 7: Semantic Zooming in smartPerform – each zoom level shows more details upon zooming in, allowing the creation of visual-spatial hierarchies.

Figure 8: left: coverflow visualization; right: "flip-book" visualization. These are simply object properties of containers, displaying the containing objects in this specific visualization and providing certain means of interaction (such as swiping).

Furthermore, smartPerform provides users with the ability to annotate any content as an overlay. This can be saved on disk, exported to USB flash drive, or send via email. It also can integrate external video sources as information objects, e.g. from a video grabber card. In combination with the graphical overlay functionality, the zoomable space of smartPerform may serve as an externalization to individual screens that have limited real estate.

Principle 5: Distributed Display Environment

While smartPerform does not incorporate a shared object data base as proposed by ZOIL, it allows multiple system entities to communicate with each other over the network. Thereby, viewports can be synchronized or different contents across displays can be linked. It also provides ways to use displays as "physical memories" to display contents that have been marked as interesting. As mentioned before, video input can be integrated in the same style as files as well, thereby going also the opposite route of integrating multiple displays and devices (e.g. visualizer, digital pens, cameras, etc.) into one shared zoomable work space.

Furthermore, an open interface allows the communication with external applications on other machines as well. Thereby, a completely new room experience can be created solely on a configurable interface level.

Principle 6: Multi-User interaction

One drawback of the "traditional" zoomable user interface approach is its limitations on a single viewport (per device). Therefore, multi-user interaction is not inherently supported by this approach. In smartPerform, we have combined the traditional ZUI approach with zoomable windows. Thereby, while still having a zoomable canvas, each user can operate and interact with individual zoomable content windows that appear on demand. We integrated this type of interaction as an alternative option, specifically suited for interaction around the table (see Figure 10).

A different approach would be to have multiple viewports. From a practical point of view, this becomes an option with the upcoming higher resolution QHD screens and we will again explore this in the nearby future.

Beside these considerations, we can handle multiple inputs from different users and thereby support independent interactions. Still, designing for true multi-user experience often requires customizations, e.g. to support not just individual interactions but individual customer journeys within a multi-display and multi-room environment (such as a museum).

Figure 9: distributed-display environments left @ Trelleborg Sealing Solutions with RFID object recognition, Germany; right @ ICT Showroom in Kohlberg.

Figure 10: Multi-user multi-window approach in smartPerform. Each window can be opened multiple times and zoomed, rotated and dragged independently.

Overall, by integrating the ZOIL design principles, smartPerform proves to be much more than a simple ZUI presentation tool. It serves as the user interface for interactive multi-display environments, as the operating system for interactive room experiences. Still, it can be used simply as a "Powerpoint" replacement to hold a talk in a non-linear manner and focusing more on the visual nature of the content.

In the following section, we will outline the use cases with existing examples more in detail and specifically focus on interactive surface experiences.

3. smartPerform on Interactive Surfaces

In the past three years, we have realized projects with smartPerform for various use-cases and scenarios in the context of presentation solutions. We would like to emphasize that many of these scenarios have not been envisioned by us three years ago – but have rather emerged from the close cooperation with our customers, with Siemens AG and IBM Corp. being the first. Besides, as it is often the case with tools, they get a life on their own and people start using them for never intended purposes. smartPerform started with our first use-case in mind: providing an easy to access and extensive information platform for walk-up and

Figure 11: Three walk up and use scenarios. Left: Porsche Tennis Grand Prix, providing visitors with information about the players and the results (2012), middle: BW Bank Germany in Sindelfingen, providing visitors of the branch to explore new bank products, right: Umweltakademie Baden Württemberg. A touring exhibition that allows visitors to educate themselves about the wildlife and parks in southern Germany.

use multi-touch displays (both horizontal and vertical mounted) on events or trade shows.

3.1 Walk-up-and-use

The walk-up-and-use scenario is one of the most common scenarios for interactive surfaces nowadays. The reason simply is that large multitouch surfaces are often still too expensive for „regular" working environments. So they are mainly used for specific installations that shall attract a large number of customers, e.g. on a trade fair. The challenge for the design of the user interface is that users a) have to be attracted to use the interface in a short time and b) probably are one-time users, so the interaction has to be self-explanatory. We could also add c) that in many cases, users don't even have a specific information need. They are merely attracted out of curiosity and will stop using the interface as soon as they figure it does not provide anything interesting for them. That is also the reason why games or simple „moving and zooming pictures" are still very popular. While not providing any specific information, they attract a large number of customers and may fascinate them long enough for a sales person to step in.

We have made the experience that ZUIs based on the ZOIL design principles such as smartPerform have tremendous potential for such use cases to provide an appealing user experience and still containing valuable information for the user. The ZUI provides an easy to understand interaction metaphor. smartPerform simply requires the user to comprehend two basic navigation actions. 1) to access an information object, simply tap on it. If the user is already accustomed to touch interfaces, she may as well use pinch-to-zoom gestures to zoom deeper into the information space. 2) to zoom out again, tap on the outer frame around the information object or again, use pinch-to-zoom for more experienced users. Thereby, we don't need any navigation widgets and the past three years have shown that users easily understand this interaction by trial & error. This also encourages users to continue to explore the model-world, as they know that they always can rely on this basic interaction to stay in control over the system.

The spatial-hierarchical layout allows designers to integrate a huge information space, especially product catalogs or other well defined information architectures are easy to integrate. The possibility to use visual metaphors to place information objects in space and not just in an abstract or tree-view hierarchy helps to put things into context and make them easier to explore and comprehend, even for unattended usage scenarios.

In figure 11 we show some of the example use cases of walk-up-and-use scenarios we realized with smartPerform.

3.2 Information platform to support sales processes on trade fairs and showrooms

A small step from a walk-up-and-use scenario is the integration of such a platform in the sales process. The interactive surface attracts customers and provides sales and consultants the chance to approach the customer or use the interactive surface right from the beginning to explain a certain matter. smartPerform and ZUIs based on the ZOIL principles in general provide the main advantage to support both of these approaches seamlessly. The interface design is both appealing and easy to use for the customer (as discussed in 3.1) and can be used to give a very specific presentation by someone who knows the information space well. Besides, the non-linear structure of content-presentation allows the presenter to tailor her story to the customer's needs and interests. The zooming also helps to engage the customer in the information journey, as they understand how information on the way relates to their specific information needs (if designed properly).

Our projects show that these kinds of uses are not limited to trade fairs. More and more companies invest in specific "presentation rooms" that allow them to showcase their company to their customers during sales meetings. We have created such a presentation room experience at ICT as well (figure 9, right) and have replicated this environment several times already. Another advantage of smartPerform and the ZUI approach here is that it is also quickly possible to define and design an application as the design space helps to shape the information architecture in a sensible way and allows the designers to focus on the content presentation instead of the navigation concept.

With smartPerform, we figured that using this kind of information presentation would also be beneficial in mobile situations. Therefore, and in line with the ZOIL design principles, we integrated an abstraction layer for input modalities, allowing us to interact with the system also with a mouse on a traditional desktop PC or laptop, as well as on Windows tablets

Figure 12: three "sales and showroom" scenarios. Left: Architare, Nagold. A furniture outlet center, using smartPerform for showcasing furniture in real size on a huge display-wall. Middle: Biobay showroom in China with different interactive exhibits. Right: Mercedes Benz Connection store concept with interactive walls and tables for exploration and car configuration[1].

and iPads. While not being the primary focus of this paper, it showcases again the variability of ZUIs and that the basic concept transfers well between different usage scenarios. For our customers this means that they can continue to use the interface and content that has been created for a trade show afterwards – during their daily sales presentations in meeting rooms.

Again, in figures 12 we present some of the real world examples for these kinds of situations.

3.3 Interactive, collaborative working environments

With interactive surfaces becoming more and more affordable, scenarios of use which integrate deeper into productive processes come to light. The idea here is that an interface such as smartPerform serves as a portal to different information objects that may become relevant in a collaboration situation, e.g. a discussion or creative meeting. Interactive surfaces, especially horizontal tabletop devices, have shown in research to have great potential for democratizing interaction and increasing group awareness (e.g. Jetter 2011). In the DeskPiles project (Jetter 2013) we have shown how researchers used a Microsoft Surface table at first without any specific interface and still profiting from the form factor. smartPerform provides a platform that can provide access to different files and information, allowing users to jointly or individually explore, annotate and discuss these and also save and send discussion results. In a joint research project with the University of Konstanz we have explored these scenarios in detail and have now been able to apply these in different real world use cases. One example within the automotive sector is to use smartPerform on tabletops for regular coordination and steering meetings around the table, allowing teams to catch up on different areas and also monitor e.g. production or sales figures. smartPerform serves as the platform to access different types of contents, in this case primarily Excel sheets with calculations and intranet webpages – allowing them to be discussed and annotated as well as supporting action plans.

3.4 Fast-Forward through additional scenarios

In the beginning, we stated that many of the use cases were not anticipated by us. To strengthen this point, we would like to flip through some more use cases that show the variability of the ZUI approach in these projects. smartPerform has been applied in Television and can be seen in ZDF formats log-in and Morgenmagazin (Presseschau, see figure 13) as a tool that allows the easy integration of social media web content (log-in) and newspaper documents (Presseschau). It has also been used for various show room installations to support real-world physical artifacts with a digital information platform (e.g. Trelleborg Sealing Solutions, Figure 9, left). It has been used in schools as a tool for creating self-learning environments on multitouch tables (Erich-Gutenberg Berufskolleg Köln). Eventually, it can also serve as a prototyping platform to quickly realize even complex multitouch applications – often we ended up using smartPerform for the end-product as well. Nokia Solutions & Networks uses smartPerform in a variety of scenarios, e.g. in different show rooms, on their main trade shows, such as the Mobile World Congress and also as a sales tool on mobile devices (laptops and tablets). Milliken & Company create huge show room experiences with the help of smartPerform on large touch walls and tables worldwide – with the first two installations now being in Shanghai and Spartanburg (HQ).

Figure 13: smartPerform @ ZDF Morgenmagazin, used for the press clipping news in a distributed display environment. Interaction takes place on the tablet which interaction commands are synchronized with the high-resolution display wall.

1 Image taken from http://www.daimler.com/dc.com/0-5-7153-49-1617988-1-0-0-0-0-0-9293-0-0-0-0-0-0-0-0.html (online 12.09.2013)

3.5 Hardware considerations

The hardware for interactive surfaces is still quite away from being standardized and completely trouble free to apply and use. While touch screens can be bought in large electronic stores, most of these are tablets and thereby limited in terms of their use in multi-user environments. Bigger touch screens often simply don't use robust enough touch recognition techniques for true multi-touch experiences. For example, many of the „all-in-one" Touch-PCs have trouble with recognizing rotation gestures with two fingers. For large scale multi-touch displays, there are currently the following solutions available: First, infrared-based touch frames (e.g. from manufacturers Citron (www.citron.de) & PQ Labs (http://www.pqlabs.com) among others), which are mounted around a display, are probably the most widespread solution for tabletops and large interactive surfaces. The technology is fairly advanced and provides very good and fast touch recognition. Further, they can not only be mounted around a single display, but can also contain display walls with seamless screens. The main drawback is that they recognize a touch slightly before touching the screen and that they cannot distinguish between a finger and e.g. a suit. Especially with tabletops, this can lead to unwanted touch-events. Infrared-based touch frames can provide limited physical object recognition by detecting the size of the touch-blob. Second, there are a growing number of capacitive screens or foils, which can be put on displays. The latter, while being also available for larger screen sizes (e.g. 70" and above) still do not provide a high enough resolution and performance for a very good multi-user multi-touch experience. The former, while being very responsive with high resolution, are only available with limited size (e.g. 46",) or extremely expensive. The advantage of capacitive screens is that they only react to fingers and not on cloths or other passive objects. Therefore however, physical object recognition is difficult to achieve.

Third, there is a number of optical touch systems, such as the Samsung SUR40 (www.samsung.com; successor of the Microsoft Surface table) or the Multitaction devices (www.multitaction.fi). The latter have drawn increasing interest, as they provide a high touch performance while also being relatively robust to external light, for which optical systems have always been very sensible. They also provide marker-based object recognition and thereby extend the design space of applications towards tangible interactions.

Additionally, touch obviously is not the only modality, which is used. Especially free-hand gesture based interaction as now widely known from Microsoft's Kinect draws interest from customers. We are still approached quite regularly by customers and asked to build an interface similar to the one from the movie Minority Report. However, we also most of the time realize, together with our customers, that free-hand gesture based interaction is still very specific in terms of the use cases for which it can be applied to. It requires trained users if it should convey more information and interaction possibilities than a game-like experience – for example to give an engaging talk or access specific information. We have also realized, that while the basic interaction principles of ZUIs work very well and feel natural in combination with touch, this is not the case for free-hand gestures. As a result, a direct transfer of ZUI interfaces seems more difficult for these input modalities.

4. Trends and Challenges

The one trend and challenge that stands out is that more and more customers expect a highly integrated solution that includes software considerations, display technology, interaction technology together with architectural understanding and design. Everything packaged together with a high user experience, as they have come to expect from their personal smartphones and apps. It is not sufficient in this area to focus on software alone – the current hardware technology requires developers to take the hardware limitations into account and design for them. Besides, we see an emerging trend that the interaction moves from individual exhibits towards holistic room experiences and well defined interactive customer journeys. We have addressed this trend by integrating a flexible interface to other devices and software, which allows us to create such experiences with smartPerform. An interesting approach here is the combination of interacting with an information space and using this interaction as implicit input for other attached systems. For example, in a United Nations Habitat

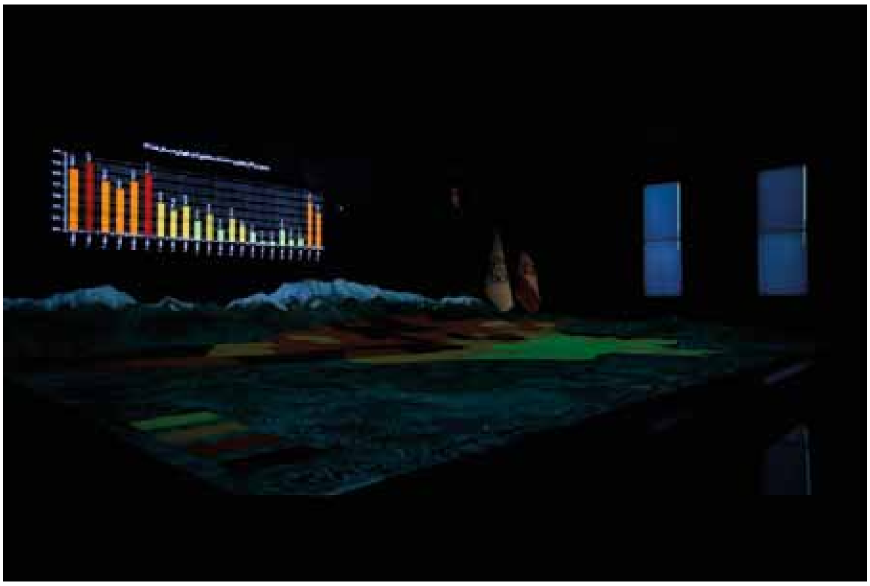

Figure 14: Tehran Urban Observatory. In the front is the physical city model with geographical related data projected. In the background is the information (e.g. statistical figures) that has been selected in smartPerform and which has triggered the projection.

project in Tehran, we used the interaction in smartPerform on a large display wall to trigger the information projection on a huge physical model of the city (see figure 14). The user thereby is able to navigate the information space as always – however, that information is implicitly and magically used to trigger further actions with other systems. We believe that in here lies the upcoming trend for engaging and fascinating interactive spaces, providing the kind of magic that thrills users while also having the potential to provide important and otherwise difficult to access information.

To summarize, this paper has shown that ZUIs do deserve future consideration for interface design and that the ZOIL paradigm and design principles provide an excellent basis to design interactive surface environments. With smartPerform, we have developed a tool that is successfully used by a wide range of customers throughout the world for very different purposes in the context of interactive surfaces. Our business success with yearly growth rates of 50% and seven-digit revenue for 2013 show the practical relevance of the ZOIL approach and the potential of zoomable user interfaces. It seems that Apple also thinks in a similar direction – the new iOS incorporates a ZUI navigation through the apps and app-folders.

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