A Virtual Reality Couch Configurator Leveraging Passive Haptic Feedback

Figure 1: A customer experiences the VR couch configurator. Her view is displayed in the background for accompanying people to see. The sales expert on the right configures the couch according to the customer's requests and controls the VR experience.

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Abstract

When configuring furniture during sales consultancy in a furniture store, customers are usually confronted with abstract 2D drawings or simplistic renderings of the discussed configuration on a display. We present a novel application based on virtual reality (VR) to support furniture store consultations. Our system allows customers to elaborate different configurations of a couch in dialogue with a sales expert and lets customers experience them through immersive VR in a variety of virtual environments. While the sales-expert can modify the couch layout and fabric, the customer can stay immersed and experience a realistic tactile feeling of the configured couch through passive haptic feedback provided by a sample piece the customer can sit on. A preliminary field study in a furniture store showed that the system is immersive, conveying realistic impressions of the couch configurations. Customers perceived the VR configurator as useful since it would make their purchase decisions easier.

Author Keywords

Virtual reality; passive haptic feedback; application; furniture configuration; immersion; user study.

CCS Concepts

•**Human-centered computing** → **Virtual reality;** *Field studies; Haptic devices; Collaborative interaction;*

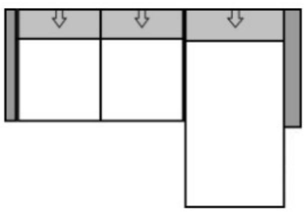

Figure 2: Traditional visualization of the couch configuration in Figure 4: a 2D layout sketch.

Introduction

Many retail domains are facing the challenge of an increasing demand for product customization. In furniture stores, this is especially important since the items bought by the customers become an integral part of their everyday environment at home for many years and investments can be significant. Thus, when buying a new couch, for example, it is common that customers first explore the models that are physically available in the store and later sit together with a sales expert to configure their model of choice in a sales consultancy dialogue. As furniture is usually configured in terms of layout, functionality and material, customers are confronted with uncountable many possible configurations. From all those, they need to pick one that matches their technical, spatial, financial and personal constraints.

To support this step of personalization during sales consultancy, furniture stores usually utilize editor applications that allow sales experts to adjust configurations according to customer requests. These tools typically present a 2D line drawing or simplistic 3D rendering of the configuration. However, such 2D sketches and simple renderings still can be too abstract for customers. Although 2D layout sketches of a couch configuration can display spatial proportions and exact measures (e.g. the width, height and length of the configured couch), it is still up to the customer to imagine the real-world appearance in terms of shape, size, functionality, and material. If this process is too abstract and cumbersome for a customer, furniture stores can experience sales losses due to wrongly imagined configurations, purchase delays, and unsatisfied customers.

In this paper, we present a novel system designed to support sales consultancy in furniture stores, leveraging immersive virtual reality (VR) to address this problem. Our system aims to provide customers deciding on a couch with a realistic impression of the considered configurations that are close to their real-world appearance. By this, the system aims to support customers in finding the right layout and material for a specific couch model. Through immersive 3D visualizations, customers can perceive the size of the configurations and picture them in different immersive virtual environments (IVEs). To align the virtual experience with the real world even further, our system employs the technique of passive haptic feedback [2] as users can sit on a sample piece of the physical couch model during their experience. By this, our system simulates the tactile feeling that the customer can expect from the final product.

We contribute the concept and implementation of our proposed system, and report the promising results of a first field study in a local furniture store.

Background & Related Work

Furniture Configuration & Visualization

The traditional way of visualizing furniture configurations, such as couch layouts, is by means of 2D outline sketches as in Figure 2, or simple rendered images. Such representations are presented to the customer either on a printed sheet of paper, a mobile device, or a desktop or TV monitor in the store, e.g. at the desk of the salesperson. Similar visualization approaches are also used, for example, when planning kitchens. In contrast to our application scenario of couch configuration, however, kitchen plans are usually based on exact measurements of the available space prepared in advance of the configuration. When looking for a couch, customers usually do not bring an exact plan of their available space but need to imagine how the piece of interest would look like in their home environment. Our approach targets this phase of configuration visualization and replaces the traditional formats by an immersive VR simulation of the couch configuration under consideration.

Figure 3: The VR couch configurator booth in the furniture store. The image shows the physical couch providing passive haptic feedback. The projection in the background is used to display the HMD view of the immersed user during the experience.

Figure 4: Virtual Reality (VR) rendering of an L-shaped couch configuration.

Virtual Reality Visualization

Through visual stimulation, VR lets users experience simulated, immersive virtual environments (IVEs). Large-scale projections [6] or head-mounted displays (HMDs) enable the visual view of a virtual surrounding and users can experience a sense of presence in the IVE [8]. This unique feature of VR as a human-computer interface encourages its use in a variety of contexts [3]. Recent research proposed the use of VR in professional medical [9] or consultancy situations, for example when discussing business process models [12]. We leverage the spatial visualizations that VR can convey to provide users with realistic impressions of configured couches. Closely related to our approach are upcoming VR approaches used for communicating configurations of car interiors [1, 4]. Providing realistic impressions of the cockpit environment, here, immersive VR supports the sales dialogue. Our approach leverages the immersiveness of VR during the product customization phase, transferring the concept to furniture retail.

Haptic Feedback for Virtual Reality

To maximize immersion and the user's tendency to feel present in the IVE, our system provides a multi-sensory experience. To simulate the feeling of sitting on the configured couch, we integrate haptic feedback into the experience, stimulating the user's tactile senses along with the visual senses. Following the Active-Passive Haptics continuum [13], approaches are commonly classified as being active [10], passive [2, 7], or mixed [11, 13, 14]. In contrast to active haptics, passive haptic feedback, as implemented in our system, refrains from involving actuators but instead provides highly realistic tactile and kinesthetic perceptions through physical proxy objects [2, 5, 7]. Here, physical counterparts are spatially registered with virtual objects and represent them in the physical world. As a consequence, users visually perceive the IVE while feeling appropriate haptic sensations as they interact with physical twins. Insko [2], for example, leveraged low-fidelity styrofoam proxies to simulate the physicality of a virtual kitchen.

The combination of VR and passive haptics to enhance professional consultancy situations has been proposed in previous research, e.g. in the context of business process consultancy [12]. In this work, we introduce the concept of passive haptics to the domain of professional furniture configuration in order to enhance the customer experience. To achieve this, we leverage the realistic tactile feeling of sitting on a real couch while being immersed in VR, and combine it with the visual flexibility of VR, i.e. the freedom to experience different layout configurations and colors visually.

Concept & Implementation

Our system was developed in cooperation with a large local (German) furniture store[1]. When designing the system, we consulted with sales personnel and asked them about the usual process of selling furniture and the tools involved. The interviews revealed that customers usually start with browsing through the store to find models that look pleasant. When suitable models are identified, customers sit down with a sales person to refine the choice by adding or removing extensions like armrests or longchairs to the configuration. Picking a color and material for the couch is done by browsing through large binders, which hold pieces of sample material. Our VR couch configuration system is based on this general workflow.

The system is split into two components. For the customer side, we implemented a VR interface using Unity. The editor component, which is operated by the salesperson, was implemented as a website. We set up the system in a dedi-

[1] Möbel Martin Saarbrücken: https://www.moebel-martin.de/standorte/saarbruecken/

Figure 5: The *Virtual Booth*, *Apartment*, *Mirror Room*, and *Miniature Room* scenes.

cated area (booth) in the furniture store, in which an exemplary couch was located. Next to the couch, a desk holding a touchscreen to be used by the salesperson was installed. Figures 1 and 3 show the booth setup. We opted for the wireless version of the HTC Vive Pro VR HMD as it lets users roam freely and provides a high visual quality. For calibration, two Vive Trackers are placed on the two armrests of the couch to register the physical couch in the IVE.

With the planner interface shown in Figure 6, the salesperson can modify the couch configuration on behalf of the customer. We deliberately kept the control of the planner interface to the sales expert so that the customer can focus on the VR experience. The salesperson can pick from several modules (i.e. longchairs, corner pieces, seat modules, etc.) which can be snapped to valid positions. To change the color or material of the couch, the salesperson can trigger a color presentation mode, shown in Figure 7. Upon activation, several spheres with different colors and materials appear in front of the customer. The spheres are numbered so that customers can easily communicate to the salesperson the color that should be applied. To accommodate all functions of the system, we created several scenes that the salesperson can switch and present to the customer:

Virtual Booth | Entering the Virtual Reality
The *Virtual Booth* scene shown in Figure 5 resembles the physical booth in which customers enter VR. After sitting down on the couch and putting on the HMD, customers find themselves in an open space that only has the red couch and the desk in it. We chose this virtual abstraction of the real booth as an entry point to ensure a smooth transition into the IVE even for users who are not accustomed to VR. As users find themselves sitting on a red couch that is spatially registered with the physical couch, a common reference point is provided when entering the IVE.

The Apartment | Experiencing the Couch in Context
In the *Apartment* scene, shown in Figure 5, we took full advantage of VR by placing the couch into a fully furnished virtual apartment. The scene demonstrates “natural” lighting and accessories to provide a living room context.

Mirror Room | Inspecting the Couch from all Sides
Although our system supports getting up and roaming freely in the IVE, some customers might prefer to stay seated during the configuration session. This is why we added the *Mirror Room* scene shown in Figure 5. Being seated on the the configured couch, the user is surrounded by duplicates of the couch on the left, in front, and to her right, allowing her to inspect the couch from different perspectives. When turning around, she can see the backside of the couch.

Miniature Room | Comparing different Configurations
While the previous scenes were designed for showcasing one specific configuration, the *Miniature Room* scene shown in Figure 5 enables a comparison of three couches at a time. This is specifically useful when comparing different colors or layouts. Here, the customer finds herself sitting on one of the configurations with the others rendered on each side. In front, the user can see a small coffee table with the three compared couch configurations presented on slowly spinning discs, each illuminated by a spotlight.

Field Study
We conducted a field study during a weekend open for business in the furniture store with the support of previously instructed sales experts. To assess the user experience, acceptance, and immersion of the system, as well as how customers perceive the VR couch configurator, we asked shoppers after their VR experience about their opinion and impression. In contrast to a lab study, this setup allowed us to record meaningful feedback and the actual behavior of

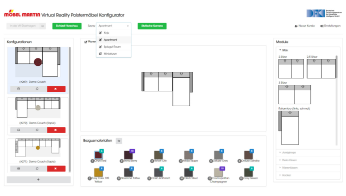

Figure 6: Planner interface to configure the couch in the IVE.

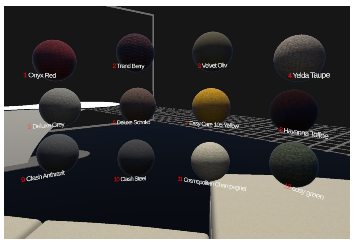

Figure 7: HMD view during the color presentation mode.

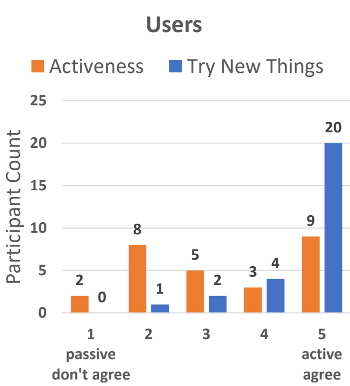

Figure 8: User behavior and attitude towards new technologies.

users interacting with our system, since participants experienced it in the context of their real shopping activities, not as part of a simulated shopping journey. As an incentive to participate in the interview after the experience, shoppers were offered a coupon in the store's local cafeteria. When the VR configurator was not in use, employees and experimenters actively approached shoppers, highlighting the presence of the VR couch configurator in the store.

Procedure

For two days, an employee of the store was readily available for customers to try out the VR configurator, guiding them through the experience. In the course of the experience, each participant was introduced to the different functions of the VR configurator and various couch layouts were configured. While a participant was immersed, two interviewers observed his interaction with the system from a distance. The interviewers recorded the time spent in VR and took notes regarding the user behavior, e.g. by rating on a 5-point scale how passive (= 1) or active (= 5) the shoppers engaged with the VR configurator. After the VR experience, the interviewers asked the customers if they would like to participate in a survey. The survey assessed their previous VR experience, the user experience and acceptance of the system, the helpfulness of the VR configurator for deciding on a couch, their favorite IVE, as well as their attitude towards new technologies. Participants could also comment on the benefits and drawbacks of the VR couch configurator and answers were recorded by the interviewers on iPads.

Participants

N = 27 (15 female, 12 male) customers agreed to participate in the post-VR interview. The majority (n = 14) of them were between 25 and 39 years old, followed by participants in the range of 40 to 59 years (n = 9), and most of the participants were accompanied by their partner (n = 18), only 2 customers participated alone in the VR experience. Participants were, overall, only very little or not experienced with VR at all. 16 participants had never worn a VR HMD before, 6 participants wore a VR HMD once and only 5 participants experienced VR a couple of times before. To assess their attitude towards new technology in general, participants stated their agreement to the following statement on a 5-point scale from 1 (= I do not agree) to 5 (= I agree): "*I generally try out new things before others do.*". The responses are summarized in blue in Figure 8, showing that the vast majority of the customers that tried out our configurator can be considered early adopters.

Results

Participants on average spent 2.50 min (SD = 0.75 min) in VR, and themselves on average estimated to have spent 3.70 min (SD = 1.48 min) in VR when asked after their experience. The participants' user behaviour was classified by the experimenters on a 5-point scale. Low values correspond to a passive, consuming user behaviour while higher ratings describe that participants actively participated in the VR experience, e.g. walked around while in VR, closely examined the configurations, and actively voiced their configuration requests. As can be seen in orange in Figure 8, our set of participants covered the complete spectrum.

To assess the immersiveness of our VR configuration experience, we asked the customers how strongly they felt to sit on the virtual couch configuration (orange), and as how realistic they perceived the virtual couch representation (blue). As can be seen from the results in Figure 9, customers rated the VR configurator as immersive and the virtual experience as realistic. Figure 10 shows that the *Apartment* scene was favored across participants, followed by the *Miniature Room*, the *Virtual Booth*, and the *Mirror Room* on the last rank.

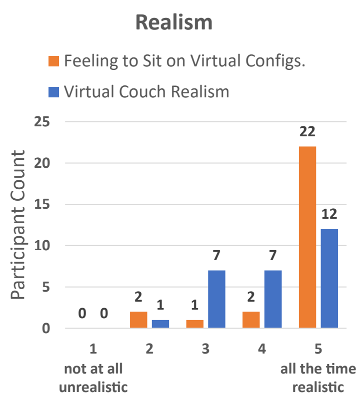

Figure 9: Perceived realism of the VR couch experience.

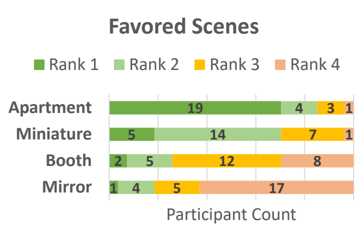

Figure 10: Ranking of the different scenes.

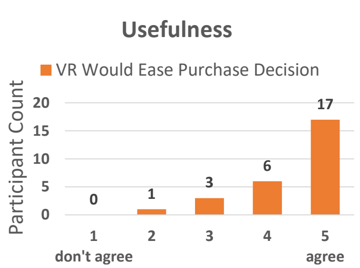

Figure 11: Usefulness of our system as rated by participants.

When asked if the VR configurator would make their purchase decision easier, 85% of the participating customers (n = 23) agreed, as can be seen in Figure 11. To this end, we also wanted to know how much time customers would be willing to invest to digitize their own living room before coming to the store to configure their couch in VR. Over 65% of the participants (n = 18) stated that they would be willing to invest at least 30 min of their time in digitization.

Discussion

The general feedback of the customers was very positive. The observations showed that the concept of the VR configurator is well suited for both active and passive users. Although the majority of the participants had only very little to no previous VR experience, the concept was generally well received. The VR configurator was perceived as immersive and the visual impression of the couch configurations as generally realistic. The customers in our field study perceived the VR configuration experience as useful, in that it would make their purchase decision easier.

The biggest point of criticism was the rendering quality of the virtual materials of the couch. Some participants described the representation of the material as “artificial”, that it looked like “plastic”, that it was too “smooth” and commented that they could not tell if it was leather or textile. It was also noted by some participants, that the level of detail of the couch modules should be higher. To improve this, we will enhance the material rendering in future iterations of the system, e.g. using more sophisticated normal, specular, and occlusion maps. Furthermore, some users reported that they experienced motion sickness. To counteract this, we plan to integrate smooth transitions and fades during scene changes, and animations during the couch configuration process. In the color presentation mode, many participants tried to touch the floating spheres with their hands.

While a direct interaction with the spheres was not integrated in the evaluated version, we plan to add support for this by integrating hand tracking. Furthermore, one participant remarked, that he/she felt alone when in VR. While we projected the HMD view in the real environment for bystanders to see, future work could explore how non-VR users can participate in the configuration experience.

Lastly, many participants expressed their desire to chose from more couch models and to experience their own living room in VR. In a focus group with furniture store customers, we plan to elaborate this aspect in more detail. Moreover, future studies will investigate the impact that the additional haptic feedback has on the experience.

Conclusion & Outlook

We introduced a first prototype of a VR couch configurator for use at the point of sale. Assisted by a salesperson, it allows customers to step into VR and look at, configure, and compare different couch configurations. As opposed to classical approaches like 2D sketches, with our system, the customer can immersively experience the entire configuration process. We evaluated our approach in a pilot field study in a large local furniture store. The overall feedback of furniture store customers was positive and the VR configurator was found to be immersive and useful. These results open up the way for improvements like direct in-VR customization, more detailed textures or the possibility to integrate the own virtual living room.

Acknowledgements

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REFERENCES

[1] AUDI AG. 2017. Audi launches Virtual Reality technology in dealerships. Online. (30 August 2017). Retrieved January 1, 2020 from https://www.audi-mediacenter.com/en/press-releases/audi-launches-virtual-reality-technology-in-dealerships-9270.

[2] Brent Edward Insko. 2001. *Passive Haptics Significantly Enhances Virtual Environments*. Ph.D. Dissertation. University of North Carolina at Chapel Hill, USA. http://www.cs.unc.edu/techreports/01-017.pdf

[3] Jason Jerald. 2016. *The VR Book: Human-Centered Design for Virtual Reality*. Association for Computing Machinery and Morgan & Claypool, New York, NY, USA.

[4] Marcus B. Korinth. 2018. *Development and Evaluation of a Virtual Reality-Based Car Configuration Human-Computer Interaction Concept*. Master's thesis. Ulm University. http://dbis.eprints.uni-ulm.de/1646/

[5] Felix Kosmalla, André Zenner, Marco Speicher, Florian Daiber, Nico Herbig, and Antonio Krüger. 2017. Exploring Rock Climbing in Mixed Reality Environments. In *Proc. CHI EA '17*. Association for Computing Machinery, New York, NY, USA, 1787–1793. DOI: http://dx.doi.org/10.1145/3027063.3053110

[6] Torsten Wolfgang Kuhlen and Bernd Hentschel. 2014. Quo Vadis CAVE: Does Immersive Visualization Still Matter? *IEEE Computer Graphics and Applications* 34, 5 (Sep. 2014), 14–21. DOI: http://dx.doi.org/10.1109/MCG.2014.97

[7] Adalberto L. Simeone, Eduardo Velloso, and Hans Gellersen. 2015. Substitutional Reality: Using the Physical Environment to Design Virtual Reality Experiences. In *Proc. CHI '15*. ACM, New York, NY, USA, 3307–3316. DOI: http://dx.doi.org/10.1145/2702123.2702389

[8] Mel Slater. 2009. Place Illusion and Plausibility Can Lead to Realistic Behaviour in Immersive Virtual Environments. *Philosophical Transactions of the Royal Society of London B: Biological Sciences* 364, 1535 (2009), 3549–3557. DOI: http://dx.doi.org/10.1098/rstb.2009.0138

[9] Maurício Sousa, Daniel Mendes, Soraia Paulo, Nuno Matela, Joaquim Jorge, and Daniel Simoes Lopes. 2017. VRRRRoom: Virtual Reality for Radiologists in the Reading Room. In *Proc. CHI '17*. ACM, New York, NY, USA, 4057–4062. DOI: http://dx.doi.org/10.1145/3025453.3025566

[10] Mandayam A. Srinivasan and Cagatay Basdogan. 1997. Haptics in Virtual Environments: Taxonomy, Research Status, and Challenges. *Computers & Graphics* 21, 4 (1997), 393–404. DOI: http://dx.doi.org/10.1016/S0097-8493(97)00030-7

[11] Eric Whitmire, Hrvoje Benko, Christian Holz, Eyal Ofek, and Mike Sinclair. 2018. Haptic Revolver: Touch, Shear, Texture, and Shape Rendering on a Reconfigurable Virtual Reality Controller. In *Proc. CHI '18*. ACM, New York, NY, USA, Article 86, 12 pages. DOI: http://dx.doi.org/10.1145/3173574.3173660

[12] André Zenner, Sören Klingner, David Liebemann, Akhmajon Makhsadov, and Antonio Krüger. 2019. Immersive Process Models. In *Proc. CHI EA '19*. Association for Computing Machinery, New York, NY, USA, Article Paper LBW0128, 6 pages. DOI: http://dx.doi.org/10.1145/3290607.3312866

[13] André Zenner and Antonio Krüger. 2017. Shifty: A Weight-Shifting Dynamic Passive Haptic Proxy to Enhance Object Perception in Virtual Reality. *IEEE Transactions on Visualization and Computer Graphics* 23, 4 (2017), 1285–1294. DOI: http://dx.doi.org/10.1109/TVCG.2017.2656978

[14] André Zenner and Antonio Krüger. 2019. Drag:on – A Virtual Reality Controller Providing Haptic Feedback Based on Drag and Weight Shift. In *Proc. CHI '19*. ACM, New York, NY, USA, Article 211, 12 pages. DOI: http://dx.doi.org/10.1145/3290605.3300441