TOOLBOX

Getting started with Virtual Reality

As a designer you might be familiar with various forms of concept representations, such as (animated) sketches, storyboards or physical prototypes. These representations can facilitate communication with stakeholders such as end-users. Involving end-users in the early stages of the design process allows you to ask what end-users think of a product concept, see how end-users would use a product concept or even ask end-users to assist in the definition of a product concept.
When developing new, complex or interactive products, 'traditional' concept representations sometimes fail to fully convey the product, interactions or use context. Presenting a product concept in a concrete use context or use situation makes it easier for end-users and other stakeholders to understand the product concept. For example, when evaluating the user interface of a new printer, it is important to not only show the screen and buttons, but also the printer of which the user interface is part. This article explains how Virtual Reality (VR) can be used to create realistic and representations of future products, user-product interactions and use contexts.

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Information about the author
Jos Thalen studeerde in 2009 af als industrieel ontwerper aan de Universiteit Twente en begon daarna bij de vakgroep 'Ontwerp, Productie & Management' als promovendus aan onderzoek over de toepassing van Virtual Reality in vroege stadia van een gebruikersgericht ontwerpproces. Het werk valt onder de onderzoeksgroep 'Use Anticipation in Product Design', onder leiding van Mascha van der Voort. Binnen deze onderzoeksgroep wordt gewerkt aan tools en methoden om ontwerpers te helpen om 'gebruik' en 'gebruikers' te begrijpen en deze kennis toe te passen in het ontwerpproces. Tijdens zijn promotie startte Jos samen met Mascha van der Voort Invocate (www.invocate.nl) op. Invocate is een adviesbureau voor user-centred design, waarbij de toepassing van VR als ontwerptechniek een van de speerpunten is.

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VR technologies create an alternative reality in which worlds, objects and characters can be experienced that may not yet be available in reality. While VR is generally associated with movies and science fiction, it actually spans a wider range of technologies, many of which are now available off the shelf. Traditional VR technologies such as 3D interactive environments, haptic gloves and head mounted displays have slowly evolved into 'consumer products' such as the Nintendo Wii, the Kinect, 3D displays and more recently Google Glass, the Oculus Rift and the Leap Motion.

By deploying these technologies in the early stages of a User Centred Design (UCD) process, VR can:

- provide an interactive and realistic confrontation with future use situations;
- make complex situations and information accessible to all stakeholders;
- support early stage concept generation, presentation and evaluation.

Together these opportunities help with eliciting more profound insights and feedback from end-users in the early stages of the design process, and consequently contribute to creating products that suit end-user needs and expectations.

Background

In practice VR applications are only relevant if you are able to realise them through an effort that is proportional to the benefits you get in return. Furthermore, designers can not be expected to spend too much time on keeping track of new VR technologies and identifying new opportunities for deploying them in their design process.

The research presented in this article therefore investigated two aspects of using VR in UCD. Firstly, it aimed to identify advantageous applications of VR in the early stages of a UCD process (i.e. investigating the *functionality* of VR in this part of the design process). Secondly, it aimed to determine the boundary conditions for designers to realise these VR applications themselves; this addresses the *usability* of VR tools and techniques.

Both aspects were first addressed in a specific design context by conducting three industrial case studies. Table 1 lists the three VR applications that were developed during these case studies. By evaluating the case study results across various design contexts, insights were gained regarding the effectiveness of VR applications in different design domains, as well as the boundary conditions that different designers have with respect to the realisation of these applications. Based on these insights a structured approach for the realisation of VR applications for UCD was developed. This article presents the approach and illustrates each step with examples from the case studies.

Approach

The key to successfully deploying VR in early stage UCD activities is to be able to select the right tools for preparing and executing a desired VR application, as illustrated in figure 1.

- The *VR application* describes the design activity in which VR is applied. The application involves *designers* and internal and/or external *stakeholders,* who have a shared goal that is to be achieved through an activity (e.g. concept generation, usability evaluation or a design review).
- The *execution tools* provide the required hardware and/or software to run the application. For example, if the application involves a workflow evaluation in an office environment, the execution tool could be a 3D game engine that provides an interactive walk-through in which workflows can be acted out and evaluated.
- *Preparation tools* are used to prepare the VR application, and could for instance involve the creation of 3D models or virtual object behaviour. Depending on what is to be prepared, the preparation can be carried out by designers themselves, or by experts in other fields (e.g. programming).

Table 1. The VR applications developed during three industrial case studies

Case study applications	
Virtual Printshop The Virtual Printshop improves the realism of product evaluations in the early stages of the development process. In usability evaluations the product's use context can play an important role in triggering feedback from either end-users involved in the evaluation, or from designers themselves. The Virtual Printshop provides a realistic and interactive virtual environment in which virtual product models can be experienced, for instance by acting out workflows or specific use scenarios.	
Virtual Personas Virtual Personas are virtual user representatives that can be used to create and visualise future use scenarios. Virtual Personas enable designers to act out virtual scenarios in a very early stage of the design process. The virtual personas used in these scenarios represent specific user groups that can be used to review a new product concept from these specific points of view.	
Virtual Annotation The Virtual Annotation application enables multidisciplinary design teams to collaboratively review and annotate product concepts in a very early stage of the development process. The visualisation of the product and its use context can help with identifying, evaluating or validating initial product requirements, but also with brainstorming about new product functionality.	

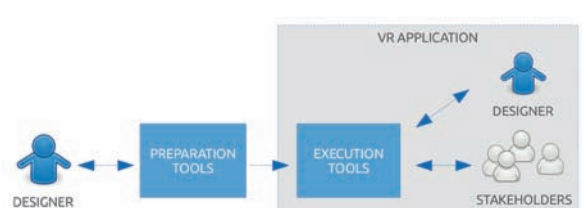


Figure 2. Terminology used to depict the different elements involved when using VR

Based on the experiences gained while developing the three case study VR applications, the following approach has been established:

- *Exploration*. Become aware of what VR is, and define a VR application that is beneficial to your design process;
- *Specification*. Determine boundary conditions for the VR application, and derive requirements for its realisation;
- *Realisation*. Acquire the appropriate means to realise the desired VR application and embed the application in the existing design process.

The following subsections further describe these steps, and illustrate them using examples from the three case studies.

Exploration

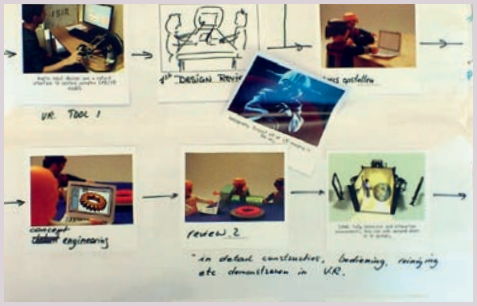
The aim of the exploration phase is to determine which design task is to be facilitated by VR technologies. When brainstorming about VR it is quite tempting to think of all the possibilities the technology offers, without reflecting on *why* you would use it. The case studies have shown that the more a VR application is defined in terms of what design activity is supported (e.g. 'the application should support our usability evaluations', or 'the application should help us with conducting design reviews'), the easier it is to identify tools that realise this application.

Howto?

You can conduct the exploration yourself, for instance by conducting desk research involving academic and industrial resources to establish an overview of available VR technologies. These technologies can be matched to specific challenges or bottlenecks in the design process that you would like to address. In the case studies a workshop approach was used. This 3 hour workshop, which is facilitated by a VR expert, involves a multidisciplinary group of about 10 people involved in the design process. Using visual storyboards, the participants first identify bottlenecks and challenges in the design process that could be addressed by VR technologies (see table 2).

Table 2. The VR exploration workshop

VR exploration workshop
The workshop is a three hour session involving a multidisciplinary group of about 10 participants related to the design process of the company, and is structured as follows. *Introductory presentation* - This presentation explains the purpose of the session and briefly introduces VR by presenting several examples of technologies. *Presentation of example storyboards* - The facilitator presents four *animated storyboards* that were prepared earlier. The storyboards visualise different applications of VR in the company's design process. *Individual storyboard* - After showing the example storyboards, participants are asked to generate their own storyboards by modifying the example storyboards. *Group storyboard* - After discussing the individual storyboards, groups of three to four participants are formed based on similarities in storyboard themes. The groups merge their storyboards into a group storyboard. *Wrap-up* - During the wrap-up group storyboards are presented to the entire group. The aim of these presentations is to share and discuss the group storyboards, and to reach consensus about which of the group storyboard presents the most interesting storyboard for further development.



Workshop participants creating storyboards
An example of an individual storyboard describing the use of several forms of VR in the design process

Table 3. Application demonstrators can be used to investigate specific application characteristics, such as the required level of realism or the required interaction modality

Case study examples

The following findings are examples of the results that were obtained by reviewing the application demonstrators with designers.

- *Visualisation quality*. Detailed models are not always required to give external stakeholders such as end-users an impression of an integrated and realistic product and use context. In early stages of the design process the models should be recognisable rather than *realistic*.

The Virtual Printshop demonstrator showed low (left) and high (right) levels of visual quality in order to determine how this affects the experience of the virtual environment

- *Interaction modalities*. Using motion tracking to control virtual personas (represented by 3D avatars) turned out to be less effective than expected. The designers preferred regular mouse and keyboard controls because it allows for a more detailed control of the avatar's movements.

The demonstrator for the Virtual Persona application showed that designers preferred manual control of the avatars (on the right) instead of motion tracking (on the left)

Having identified these opportunities, they use storyboards to visualise their desired VR applications by indicating what kind of technology could be used, why and when it would be used (e.g. what design activity is facilitated) and who would be involved in using it.

The main advantage of the workshop approach is that the company does not have to invest time in getting to know the current state of the art in the field of VR. Furthermore, the expertise of the workshop facilitator can be deployed to assess the matches between specific design challenges and VR technologies.

Specification

Especially when there are questions about the technical characteristics of the desired application, the creation of *demonstrators* or *prototypes* (see table 3) is a vital step towards establishing the focus of the final VR application;

- It will give insight into the validity of the desired application (i.e. does the VR application indeed contribute to a particular UCD activity?)
- It will tell you whether or not you should invest in e.g. creating high-fidelity 3D models or buying new hardware or software

The use of demonstrators is most effective when there is a balance between the investments made to create the demonstrators and the resulting feedback and insights. While the demonstrators need to have sufficient 'depth' to properly experience a specific functionality (e.g. motion tracking), it should be kept in mind that they are still (disposable) demonstrators.

Howto?

There are several off the shelf options available for demonstrating specific VR technologies, such as *BuildAR* for demonstrating augmented reality applications, Microsoft's *Kinect SDK (Software Development Kit)* for creating gesture recognition applications and the *Surface SDK* for creating multi-touch applications. These tools typically provide restricted yet user friendly access to the core functions of a specific technology, which makes them quite suitable for developing demonstrators. Furthermore, most SDK's provide a collection of examples that can often be used as a starting point for a more tailored demonstrator.
More advanced development environments and programming interfaces such as *Blender*, *WebGL* and *Artoolkit* provide more versatile platforms for developing demonstrators, but also required additional skills (e.g. programming and/or 3D modelling).

Realisation

The final step of the approach is to select appropriate preparation and execution tools. The functional requirements (or boundary conditions) for these tools have been established during the specification phase. When selecting the final preparation and execution tools, it was found to be important to carefully consider the existing tool chain before looking for new tools. Resources (people, skills and software) are often already being used for other purposes, and can be re-used for the realisation of VR applications.

The following guidelines have been derived from experiences gained in the case studies.

Consider your current tool chain

- Companies involved in product development often already possess the tools and skills required for the preparation of 3D assets (e.g. CAD software).
- Modern CAD applications also provide support for executing VR applications. Sometimes the functions are built-in (e.g. an interactive walk-through function), while plugins can also help with providing specific functionality (e.g. model annotations).
- If your VR application requires integration with other tools such as simulation software (e.g. Matlab), it is recommended to focus on larger tool suites. These suites generally provide more interfaces to external tools and data formats than smaller task specific tools.

Consider your resources

- Design and engineering departments use stripped-down versions of CAD models for making quick renders or to share with clients. These 'light weight' models can also be used for VR applications.
- Model repositories such as Google 3D warehouse provide a good source of 3D assets that can be used to support the preparation of the VR applications. The repositories provide generic models such as furniture, vehicles, humans and scenery objects.

Consider the desired scope of VR applications

- If you only intend to realise a single VR application, task specific tools such as BuildAR or SweetHome3D are sufficiently capable and easy to use without extensive training.
- Tool suites such as 3DVIA, Blender or NX provide an integrated solution for the preparation and execution of the application, but require more extensive training. They do however support a wider range of VR applications than task specific tools.

Conclusion

The three case studies presented in this chapter illustrate how VR can facilitate various UCD activities in the early stages of the design process by providing an interactive and integral representation of a future product and use context. This representation facilitates communication between designers and end-users (for instance by improving the realism of a usability test environment) as well as communication within a design team (for instance by facilitating concept annotation tasks).
In addition to the VR applications themselves, the research provides a practical approach for designers to identify, specify and deploy their own VR applications. Based on the experiences gained during the case studies in which the above applications were developed, it was found that the threshold for the realisation of VR applications can be reduced by

- using low-end and/or off the shelf VR hardware and software: The increasing availability of off the shelf VR technologies have reduced the threshold for adopting VR in practice. An overview of these technologies is included in the end of this article;
- re-using tools and skills already available in the design process: On several occasions, it was found that designers already have the tools and skills to create simple VR applications, such as virtual walk-throughs (using existing models and CAD applications).

The main challenge for practitioners to get started with using VR is to identify useful applications and find appropriate means to realise these applications. The VR expo-

ration workshop presented in this article addresses this challenge effectively and efficiently. It provides you with an overview of tailor-made applications and recommendations regarding the realisation of these applications. If you are interested in doing this workshop (which takes one afternoon), please contact the author.

Samenvatting

Virtual Reality (VR) technieken maken het mogelijk om virtuele omgevingen te creëren waarin dingen kunnen worden beleefd die in werkelijkheid (nog) niet mogelijk zijn. De afgelopen jaren hebben steeds meer VR-technieken de consumentenmarkt bereikt. Denk bijvoorbeeld aan de Kinect spelcomputer, waarbij door middel van beweging en gebaren een computerspel gespeeld kan worden. Ook *augmented reality* apps, waarbij live camerabeelden en 3D-modellen worden gecombineerd tot een nieuwe virtuele wereld, worden steeds meer gebruikt voor onder andere marketing (bijvoorbeeld IKEA) en entertainment (bijvoorbeeld Layar). De mogelijkheid om 'dingen te beleven die nog niet bestaan' is ook voor productontwerpers interessant; als productontwerper werk je constant aan dingen die nog niet bestaan. De vaardigheden en materialen die ontwerpers hebben om hier mee om te gaan (zoals conceptschetsen, modellen en prototypes) zijn voor *eindgebruikers* niet altijd voldoende. Zodra je als ontwerper een eindgebruiker wilt betrekken in het ontwerpproces, bijvoorbeeld ten behoeve van een usability-evaluatie of om de reactie op een nieuw product te polsen, moet de communicatie hierop afgestemd worden. In dit artikel wordt onderzocht hoe VR hiervoor kan worden ingezet. Het artikel beschrijft drie case studies waarin VR wordt toegepast voor het ondersteunen van communicatie met eindgebruikers in een vroeg stadium van het ontwerpproces. Uit de case studies blijkt dat VR hierin inderdaad een rol kan spelen. Bovendien blijkt dat verwachte knelpunten, zoals de kosten en de complexiteit van deze technieken, mee blijken te vallen zolang je als ontwerper de juiste techniek weet te vinden. Op basis van de ervaringen die zijn opgedaan tijdens de case studies presenteert het artikel een aanpak die de identificatie van zowel de toepassing van VR als de benodigde technieken ondersteunt.

Software and hardware		
Examples from Samenvatting		
IKEA AR app	Augmented reality for IKEA products	http://www.metaio.com/
Layar AR	Mobile augmented reality	https://www.layar.com/
Software		
Sweethome3D	Easy to use interior design suite	http://www.sweethome3d.com
BuildAR	Augmented reality authoring tool	http://www.buildar.co.nz
ARToolkit	Augmented reality development kit	http://www.hitl.washington.edu/artoolkit/
Blender	3D development environment	http://www.blender.org
ThreeJS	3D rendering library for the web	http://www.threejs.org
3DVIA	Commercial 3D authoring suite	http://www.3dvia.com
Hardware		
Microsoft Kinect	Motion tracking platform	http://www.microsoft.com/en-us/kinectforwindows/
Oculus Rift	Head mounted display + tracking	http://www.oculusvr.com/
Nintendo Wii	Motion controlled game platform	http://www.nintendo.com/wii
Microsoft PixelSense	Touch sensitive table	http://www.microsoft.com/en-us/pixelsense/
Google Glass	Mobile augmented reality	http://www.google.com/glass/start/
Leap Motion	Gesture recognition	https://www.leapmotion.com/