The Virtual Reality Lab as a Synthetic Environment: From Strategic Approach to Practical Implement

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Abstract. The Virtual Reality laboratory (VR-Lab) at the University of Twente facilitates multi-stakeholder decision making processes. Using Synthetic Environments (SE) to facilitate collaboration and to visualize consequences and dependencies of choices, the lab stimulates optimal use of available expertise. The VR-lab embodies a flexible set of VR tools, software and working methods; therefore adequate facilitation of preparation and configuration of use is essential. For this purpose, a roadmap facilitates the attuning of the intents of (potential) user and the capabilities of the provider of the SE. This publication outlines the use of the VR-lab as a Synthetic Environment, as well as the preparations that a required to make that usage purposeful and efficient.

Keywords: synthetic environments, virtual reality, multi-stakeholder, decision making.

1 Introduction

Product development can be seen as a process of constantly making choices, often in consultation with multiple stakeholders from different fields of expertise. Within this team setting, developers have a need for support in communicating and for visualizing their problems and solutions, especially for gaining insight in the consequences and dependencies of choices.

This publication provides an overview of the approach, development, use and outlook of the Virtual Reality laboratory (VR-Lab) at the University of Twente [1]. This multi-stakeholder decision making laboratory facilitates the collaboration and decision making process in product development projects.

1.1 Scope

Within the field of product development, the need for support and facilitation of the various product development phases is obvious. In general, product developers also show enthusiasm for approaches that offer adequate support. Within the VR lab of the University of Twente, product developers are encouraged to address and optimize the development processes they employ in daily practice. The scope and emphasis is on supporting the decision-making processes that involve multiple stakeholders who aim

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to understand the implications of the many decisions that have to be made. Within these processes, many choices have to be made that involve multiple stakeholders. This immediately leads to complex dependencies between the choices made and the consequences thereof. These consequences are not always clear for every stakeholder involved. The VR-lab aims to give insight in the relations between and dependencies of all decisions, and to present them in the most purposeful and adequate manner. Furthermore, for the design process, it is important that such support can be delivered quickly, with minimal adjustment to the development process, the project planning and schedule. This implies that the configuration of support should be flexible and easy to adapt to different situations.

The VR-lab gives designers the ability to rely on support in the design process when it comes to cooperation (figure 1). Such support is available from the earliest stages of the development process. In these stages, it is desirable for the various stakeholders to define a common vision and understanding of the (explicit and implicit) problems that together constitute the basis of the development project. During the solution generation phase, the lab offers the possibility to clarify ideas for future scenarios using many types of visualisations and interactions. This also gives direct insight into the consequences of possible choices in areas such as safety, construction, use situation and composition. The lab adds the most added value to a process when a (large) group of stakeholders is interacting with one and the same set of information, and when they approach and handle this set in a way that best suits their own personal expertise. In this manner, the interactions and adjustments of other stakeholders to the data are immediately relevant and can be made visible. It is therefore possible to assess the collaboratively composed solution (path) based on individual expertise. In this, it is essential that every stakeholder perceives the information that is meaningful for him; therefore it must be possible to omit redundant information and information that cannot be processed. In other words, the working methods, together with the capabilities of the VR-lab should enable individual stakeholders in effectively and efficiently addressing information that is relevant for his perspective, in the context of the overall solution (path).

Fig. 1. Impression of projects in the VR-lab

2 Methodology

A product development process can be considered to be a constant trade-off between problems and solutions. To support and facilitate this trade-off, it is important that all stakeholders share an aligned vision on both. This starts with the definition of the actual design problem, rendering a shared understanding between the various stakeholders. With this, everyone can assume that the defined problem is interpreted in the same way by all participants. This synchronized start creates a situation where different backgrounds and expertise of the various participants come together and where even end-user can be involved in the process. By providing each stakeholder with the possibility to directly and explicitly communicate in his or her preferred way, the risk of misinterpretations is minimized. Each stakeholder should be involved in the process by being provided with an optimized method to contribute. Based on the supplied input, the interests and bias of each stakeholder within each stage of the process can be depicted, in which this preference is strongly related to the actual circumstances. Based on all supplied input purposeful and continuous iteration between problem definition, solution generation and the assessment is feasible.

The methodology and working methods that constitute the basis for the VR-lab allow for structured, transparent and straightforward use of different tools during product development lifecycles. Usage of these tools ranges from scenario development and serious games to what-if design and information management. The VR-lab can be compared to a workshop, in which the available (VR) tools are exposed and can be addressed as utensils in a toolbox (figure 2). In order to make optimal use of the lab, the following aspects should be taken into account, and should also be reflected in the composite approach:

- Hardware
- Software
- User
- Environment
- Information
- Knowledge
- Methodology
- Resources
- Working methods

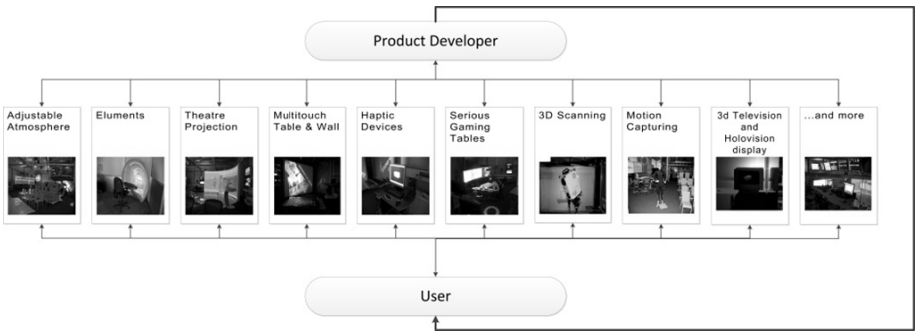

Fig. 2. Selection of multiple VR tools

The combination of the abovementioned methodology, the Virtual Reality lab and the set of stakeholders together constitute a so-called Synthetic Environment (SE). This artificial environment represents an alternative reality, which acts as commensurable to a real environment as required. To allow for natural behavior, enabling intuitive use, the interaction possibilities provided in the synthetic environment correspond to real world interactions as adequate as is appropriate. This alternative reality uses both virtual and augmented reality techniques to allow the various stakeholders to interact with it (e.g. make adjustments to it) in a way that is easier, more transparent, more purposeful and more controllable than in reality, while requiring less effort. This makes it possible to quickly evaluate multiple configurations, and also to review the consequences of possible choices. A SE can be adjusted while it is in use in real time and it therefore allows stakeholders to deal with design information in an interactive way. Therefore, it is easier to evaluate features and experiences under a wide variety of circumstances. As a result, the stakeholders become more conscious of their decisions and the related interdependencies. This is mainly because the information is presented to every stakeholder in an understandable format/way that is independent from the stakeholder's background or expertise.

These SE's prove their usefulness best in development processes of new or complex products, involving many stakeholders with various backgrounds. They can be used in nearly all phases of development processes; especially in the early stages SE's may well help to describe current and future scenarios.

The main characteristics and objectives of SE's are to ensure validity of decisions by using realistic interactions, to simulate effects in a familiar context in order to achieve a realistic image of the future environment, and to present corresponding images of future situations to facilitate negotiations about consequences of their characteristics [2].

In summary, Synthetic Environments can be depicted as well-considered compositions of possible future environments, used to give more insight into the consequences of the choices in such compositions. To enable stakeholders to experience this environment as veracious as possible, extensive use is made of virtual and augmented reality technologies. Bringing such tools to industrial practice becomes increasingly relevant, as the cost of hardware and software tend to decrease. Therefore, the ability to use SE's in smaller companies increases continually.

3 The VR-Lab as a Synthetic Environment

As with every workshop, the end result that can be achieved depends on the craftsmanship and expertise of the people using it; therefore, it is essential to adequately align the users' requirements, functional specifications and capabilities with the appropriate configuration of the lab and its tools. In other words, no fixed configuration can cater for all approaches, but a flexible and modular set of equipment can allow for quick creation of new settings.

The basic approach, as mentioned in the previous section, leads to an atmosphere in which initially a conjoint view of the problem, its setting as well as a better understanding of dependencies between all stakeholders is realized. From that systematic beginning, solution paths can be explored effectively and efficiently by employing

working methods and tools in the lab. It is without doubt that the development and realization of a Synthetic Environment requires extensive preparation in order to effectively provide substantial and useful results. This preparation often is a cooperation between designers who want to use a SE, and the host of the facility that can provide the environment.

3.1 Approach

The flexible layout and composition of the VR-lab provides capabilities within a wide variety of projects. However, this flexibility of the configuration needs clear principles as concerns the composition of attributes. Given the comparison of the lab with a workshop, it is important to adequately address the preparation in the selection of elements that together will constitute an SE. In itself, the lab is not an automatic solution generator, but it can be a facilitator to make effective and efficient use of the expertise of all attendees. In this respect, it is important to distinguish between the three categories of aspects that together constitute the SE [3], as illustrated in figure 3:

- Techniques; new techniques allow for new possibilities to acquire or present data.
- Tools: techniques can be used and combined in virtual reality tools to make them applicable in a specific scenario.
- Solutions: in combining multiple tools, a virtual reality facility is created.

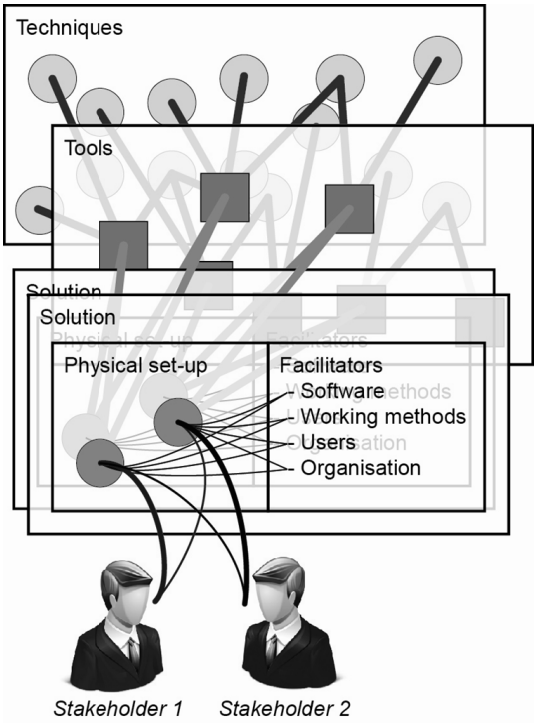

Fig. 3. Relation between techniques, tools and solutions

In order to properly prepare for the usage of a SE, it is necessary to determine on beforehand what the conditions are as concerns the desired goal, but also as concerns the technology used. Furthermore, the initiation of the desired use and the dependencies of the different stakeholders should be available on beforehand.

To be able to make optimal use of the VR-lab as a SE, it is essential to communicate the characteristics of such an environment with future users. From the perspective of the facilitator, it is important to get the right information from the future users, but that information can only be given by those users if they understand what added value a SE can have for them. This preparation should therefore be organized in such a way that the appropriate information is gathered from the prospective users in a structured way so that the data can directly be used by the facilitator to assemble the environment. This is essential to make it possible to combine the right tools based on the desired goal.

In order to prepare the assembly of a Synthetic Environment, and to communicate and explain the possibilities to potential future users, a roadmap is used as a communication and library tool [4], [5]. The roadmap is a guideline for the consulting process between the facilitator and the potential user; it guides both in determining what information is needed to execute the process and defines how the information is, or should be, interrelated (figure 4). Furthermore, the roadmap provides a blueprint on how to structure all the information generated in the start-up phase. Additionally, it provides an overview of the current state of preparation.

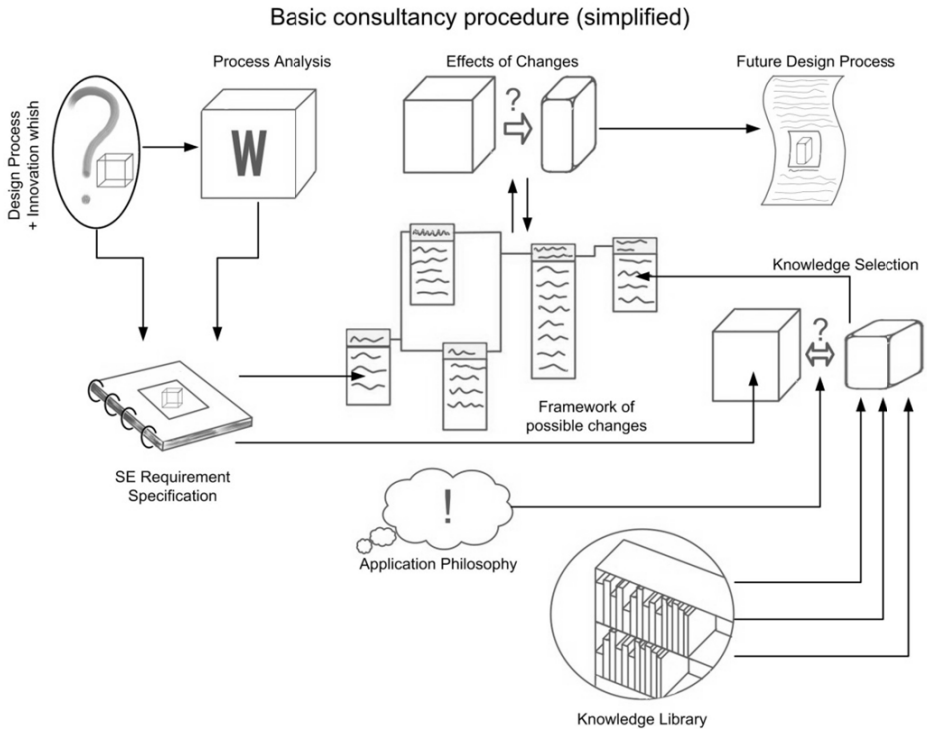

Fig. 4. Blueprint for developing and using a SE

4 Projects

Over the years, the VR lab has served as facilitator of Synthetic Environments for a large variety of projects in several phases of development. It is in the diversity of the projects that the flexibility of the use of the lab is evident. The diversification includes the number of stakeholders involved, the phase of the project, the equipment and the time required. But especially the content and objective of such projects is never the same, and does not allow for a one-to-one copy to other projects. Although the focus of the VR-lab is mainly on product development processes, it often shows that the methodology and approach is also applicable to decision-making processes in general. The core value mainly lies in the support of multiple stakeholders in creating and balancing multiple choices/decisions.

The researchers of the VR lab perceive clear similarities in the way of approach for the different projects. Because different devices and techniques are used in multiple ways, the VR-lab is a good example of a facilitator for SE's. Since the lab contains a selection of commercially available and custom made hardware and software, combinations of hardware and software that are frequently used together gradually emerge as a kind of higher-level building blocks. Every combination of VR-lab equipment and intended use in a SE allows the researchers to assess how successful the combination is or if the combination proposes any challenges. In any case, the gained experience provides input for use in future projects. In addition, during project execution, demands for adjustments and additions to the SE can be addressed. For example, additional support may be necessary in the process, which provides directions for new equipment or methods that need to be developed or purchased in the near future.

Not only the results of composing a SE often shows parallels for the researchers of the VR-lab, also the similarities in the underlying activities in establishing the SE provide ample guidance. To optimize stakeholder involvement in this, it is important to make good use of dedicated roadmaps. This makes it easier for each stakeholder to indicate and clarify the goal of the process, and makes it easier for the facilitator to come up with the most appropriate configuration of equipment, software and working methods. In addition, it gives all parties a sense of suitability and therefore brings more confidence in the choices of support and feedback methods in the environment. The roadmap simultaneously is the checklist and the guideline for the arrangement of a SE.

Future projects of the VR lab focus more on integrating different types of data/information sources. This not only results in increased integration of different types of documents, images and simulations, but mainly in using multiple types of 3D models in the environment. In addition to static virtual 3D models, the use of dynamic 3D models is explored and exploited, even in combination with e.g. tactile and haptic models. In addition, the possibilities of integrating multiple research disciplines during the exploitation of an SE are expanded. During the development and assessment of a product or environment, more information can be obtained about the potential risks, the expected maintenance costs, life cycle analysis or guidelines for suggested improvements.

In addition, the integration of 3D projected images, such as holograms, will be expanded further. The introduction of such new techniques that make it possible to view voluminous 3D models with multiple stakeholders at the same time from different angles provides easier understanding of future products and environments. As such, the transition from virtual to real, and vice versa, will gradually dissolve.

5 Conclusion

Using the VR-lab as a flexible toolbox has the inherent consequence that there is a continuous need and possibility to add new or improved tools. On the one hand this may seem to hamper the trouble-free employment of SE's in everyday practice, but more important, it also provides insight in what is expected in future tools. After every single project in the VR-lab, the design and implementation of the preparation roadmap is extended and improved, and is better aligned with the experience gained. Also, the range of available (VR) tools is constantly increasing, whereas the price of hardware and software is decreasing. This ensures that the use of Synthetic Environments for smaller project groups increasingly comes within reach. Simultaneously, it allows the VR-lab to be applicable and useful for a wider audience. The experiences of previous projects in the VR-lab also challenge the researchers to define more general implementable tools; at the same time it offers more opportunities to customize and personalize them before or even during use.

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