Heinrich C. Mayr, Stefanie Rinderle-MA, Stefan Strecker (Hrsg.): 40 Years EMISA,
Lecture Notes in Informatics (LNI), Gesellschaft für Informatik, Bonn 2020 91

Towards a Virtual Reality-based Process Elicitation System

Jannis Vogel[1] and Oliver Thomas[1]

Abstract: Today's worldwide operating companies must design their processes globally. Stakeholders within a global process cannot know each circumstance that is spread over several areas. However, digitalization and globalization lead to process redesigns that have to be discussed and reflected in process modelling workshops with various stakeholders that are more likely non-modelling experts. Hence, traditional process elicitation techniques such as interviews or modelling workshops meet new challenges in a globalized and digitalized world. A promising approach to encounter them is the use of virtual reality as a technology-based process elicitation technique. We have performed a systematic literature review and identified 32 articles to existing technology-based process elicitation techniques. Based on the identified literature a taxonomy and specific requirements for the virtual reality-based process elicitation system were derived. Additionally, the paper proposes an architecture for a virtual reality-based process elicitation system that includes today's virtual reality 360-degree recording- and hardware standards.

Keywords: Process Elicitation, Virtual Reality, Domain-specific Modelling Language, Process Modelling, Process Modelling Workshop.

1 Introduction and Motivation

Novices without any process modelling expertise face problems to model actively and correctly during process modelling workshops [RSR10]. However, the digitization calls for process modelling workshops with collective participation from all business stakeholders, especially the collection of tacit and explicit knowledge is crucial for businesses [Sm01]. Furthermore, due to global processes the circumstances from globally distributed business locations have to be reflected in process redesigns. This increases process elicitation difficulties and adds potential language barriers. A virtual reality-based process elicitation system (cf. section 4) should encounter these issues. Virtual Reality (VR) can be "defined as a real or simulated environment in which a perceiver experiences telepresence" [St92]. A comprehensive conducted research project for the use of VR in business process modelling was made by Leinenbach in 2000 [Le00]. He evolved a VR-based system to document business process knowledge with a desktop-based VR simulation of business environments that will be automatically transformed into a semi-formal event-driven process chain. Forty-five consultants were questioned regarding improvement potentials through the system and 73% of them estimate that process documentation and workshops can be enhanced. Additionally, the visualization of the process elicitation environment can increase the recall ability of information [HBJ17]. A study with 40 participants showed that they had an 8% better recall ability due to the usage

[1] University of Osnabrück, Chair of Information Management and Information Systems, Katharinenstr. 3, 49074 Osnabrück, Germany, [jannis.vogel, oliver.thomas]@uni-osnabrueck.de

of VR headsets and their associated improved immersion compared to monitors [KPV18]. Further, another study revealed that practitioners prefer storyboard design instead of semiformal modelling languages [WGK13]. Consequently, VR could be in favor to elicit processes for process modelling novices than standard process elicitation techniques due to a high degree of immersion into the real world. Moreover, VR environments can be used de facto unlimited for process elicitation [Ha15] that allows a multiple process elicitation simultaneously.

Although different process elicitation techniques exist (cf. section 3), interviews are still amongst the most effective elicitation approach [Da06]. Studies revealed that a higher theoretical modelling competency supports the reading of business process models [TVC17]. A process facilitator can partly support both tasks during a process modelling workshop. Nonetheless, carrying out a participative modelling workshop is a non-trivial task, requiring cognitive efforts and a trained modelling facilitator [SPS07]. Objectives of the research project are to support the workshop facilitator and participating domain experts in terms of a simplified domain-specific modelling language (DSML) in VR and a precise recall ability of information due to the VR-based process elicitation system. Hence, we developed the following research question:

RQ: How can a virtual reality-based process elicitation system be designed to facilitate process elicitation in particular for non-modelling experts?

The remainder of this paper is structured as follows: In section 2, the research method to execute the research project is presented. In section 3, related work regarding technology-based process elicitation techniques is represented by means of a systematic literature review. The conceptual idea behind the VR-based process elicitation system is explained in section 4. Thereby objectives and an architecture for a VR-based process elicitation system are outlined. Finally, the last section mentions limitations, discusses and sums up the paper.

2 Research Method

The research project follows the problem-oriented Design Science Research Method (DSRM) by Peffers et al. [Pe08] to address the before mentioned real-world problem. Figure 1 shows the DSRM steps and associated research activities. We identified the problem and motivated for a VR-based process elicitation system in section 1. Furthermore, we concluded a systematic literature review that results are presented in section 3 to figure out existing and related technology-based process elicitation techniques. In doing so, we found out that to the best of our knowledge no previous direct work exists that uses VR in combination with 360-degree recordings to elicit processes. Based on the identified literature, a taxonomy for technology-based process elicitation systems is developed that allows the classification of the VR-based process elicitation system. In addition, based on insights from previous related work such as virtual worlds, requirements and objectives are derived. For the identification of additional requirements, we will carry out a mixed-method approach and add behavioral research methods, i.e. quantitative studies by online surveys and qualitative studies by semi-structured interviews in the design and evaluation phase [HD13]. The presented architecture for the system (cf. section 4) constitutes an important groundwork to derive further requirements and do not purport to be complete. Lastly, to evaluate the system after a demonstration by a VR-based process elicitation workshop, a modelling session with practitioners and novice modelling users will be carried out to elicit the applicability and usability of the system.

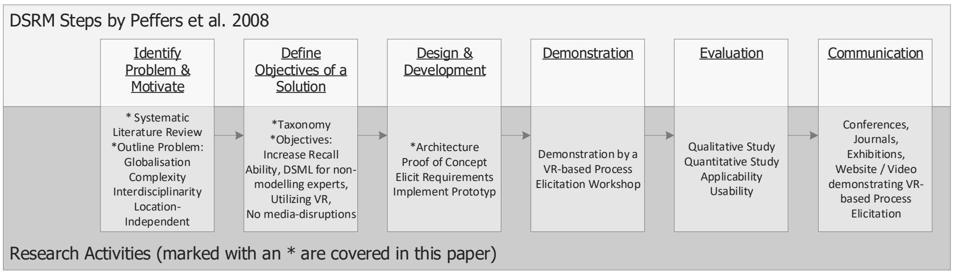

Fig. 1: Research Activities to streamline the Research Project in accordance with the DSRM by Peffers et al. [Pe08]

3 Technology-based Process Elicitation Techniques

3.1 Research Results and Classification of identified Literature

The aim of this research is the development of a new technology-based elicitation method that is not fully covered, but based on standard elicitation methods such as interviews, observations, document analysis, work diaries or modelling workshops [Sa14]. Therefore, we conducted a systematic literature review according to vom Brocke et al. [Vo09] in December 2018. The literature review process is structured by Dybå and Dingsøyr [DD08] and is depicted in Figure 2. We used the search term “process elicitation” with quotation marks and searched in the title, abstract, and full-text. We identified literature with the following databases in the field of information systems: Springer Link, Google Scholar, ScienceDirect, ISI Web of Knowledge, IEEE Xplore and AISeL. Then, we exported the articles meta-data of each query, if a query reaches results over 1000, we only imported the first 1000 based on relevance. In total meta-data of 1667 articles were collected. After that, we deleted 178 duplicates identified by the title. Based on the unique titles, we identified in a first step relevant literature and excluded 1381 articles. The including criteria was if the observed title indicates a technology-based process elicitation or modelling approach. Afterwards we used the abstract as second criteria and excluded additional 63 articles that did not fit. Lastly, we excluded 26 articles based on their full-text. Thus, we identified 17 suitable articles that include technology-based process elicitation techniques. Further overall 15 articles were identified with a forward and backward search applying the same inclusion and exclusion criteria. Thereby, we identified 8 articles with the application of a forward search. Therefore, we used the database Google Scholar and the cited by functionality. Finally, additional 7 articles are included based on the references used in the primarily 17 articles. This lead to 32 identified paper in the final set, which is mentioned in the concept matrix according to Webster and Watson [WW02] (cf. Table 1).

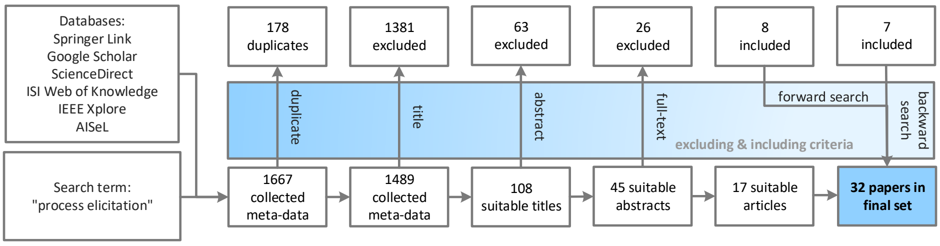

Fig. 2: Literature Search Process for Technology-based Process Elicitation Techniques (according to Dybå and Dingsøyr [DD08])

During the literature analysis, we classified the identified literature into four concepts. The first concept (I) represents if the process elicitation technique uses some kind of process modelling tool. The second concept (II) is fulfilled if the process elicitation technique is based on technology. If the paper contains a study about a process elicitation approach, the third concept (III) is satisfied. The fourth concept (IV) reflects if the elicitation approach can be applied in a workshop format. Following the main insights regarding each concept are summarized:

(I) Process modelling tools: The literature review reveals a close relationship between process elicitation techniques and the capturing of the elicit knowledge with process modelling tools. 24 articles out of 32 (~75%) use in some kind of way a process modelling tool. Notable was the extensive usage of non-standardized process modelling languages. For instance, the applied Subject-oriented BPM in the concept "model as you do" is used in virtual worlds [Ha15].

(II) Technology-based elicitation techniques: The broadness of different technologies for process elicitation is wide. Dominant technologies are virtual worlds (5), text mining or natural language processing for stories (5) and different software-based applications for smartphones or tablets (7) or even smart glasses (2).

(III) Process elicitation studies: One important study is the investigation by Leyh et al. [LBS17]. They investigated if elicitation techniques for business process management (BPM) changed during digitization. They discovered that elicitation approaches did not change, and interviews or workshops are applied with pleasure as elicitation techniques, although digitization facilitates more complex organizations and processes. However, Leyh et al. espouse the combination of classical elicitation approaches with upcoming tools through digitization e.g. automated process elicitation [SAC18].

#	Topic	Src	I	II	III	IV
	General elicitation studies:					
1	Investigation if elicitation techniques changed during digitization	[LBS17]			●	
2	Aggregated view onto elicitation techniques	[Da06]			●	
3	State-of-the-Art of process mining approaches for natural language text	[RTT16]			●	
	Virtual Worlds to enhance process elicitation:					
4	Modelling BPMN Processes in Virtual Reality	[OPM18]	●	●		
5	3D Virtual Worlds for process training	[Ay16]	(●)	●		
6	Augmenting in 3D Virtual World to elicit tacit knowledge	[Br14]		●		
7	Study about the recall of information with a virtual reality headset compared to a monitor	[HBJ17]		●	●	
8	Concept “model as you do”, virtual reality tasks are directly saved into a process model	[Ha15]	●	●		
9	Modelling through a role-playing approach in a virtual airport	[Ha16]	●	●	●	
	(Story)telling and text interpretation as a process elicitation technique:					
10	Process elicitation through storytelling technique, a story can be created with the definition of different scenes	[An13]	(●)	●		●
11	Comparison of storytelling modelling with traditional modelling	[SAC18]	(●)	●	●	●
12	Teams recall their daily work with stories, based on the stories a text mining approach identifies process elements	[DSB09]f	●	●		●
13	The interpretation of natural language leads to formal process models	[Ca16]	●	●		
14	The interpretation of the text in semantic wikis leads to process models	[DV11]	●	●		
15	Web tool to collect process stories and create process models	[SBP08]	●	●		●
	Game-based process elicitation:					
16	Process elicitation while playing a game with BPMN-like notation elements	[HS09]	●	●		●
	Digital tools that enable process elicitation:					
17	Mobile web-based modelling tool to model petri nets	[AH16]	●	●		
18	Gesture-based process modelling on mobile touch devices	[KRR12]	●	●		
19	Netsketcher a mobile tool that allows the drawing of BPMN shapes with handwritten text on tablets	[Ba11]	●	●		●
20	MOBIZ allows the collaborative creation of BPMN process models on smartphone or tablets with well-known process elements	[Ba13]	●	●		●
21	CEPE tool a Cooperative Editor for Process Elicitation: Workshop participants can draw the process through CEPE elements in a desktop-based drawing surface and share them among the workshop participants	[De03]	●	●		●
22	Study about the usage of multi-touch tables in modelling sessions	[Wi12]	●	●	●	●
23	Concept “model while you work” provides a software tool for the modelling on a tablet with easy recognizable modelling elements	[LS16]	●	●		
24	Process analyst can save contextual information during a process interview in the form of sketches	[Si12]	(●)	●		●
25	Process elicitation with Smart Glasses	[Me18]	(●)	●		
26	Comparison of tangible process modeling methods with a tabletop interface	[FSS14]	●	●		●
27 28	A table touch process modelling approach with tangible modelling blocks	[OS14] [KO15]	●	●		●
	Event logs/activity recognition based on cameras, sensors and wearables:					
29	Technology-based process elicitation approach realized through the use of different cameras that detect activities during process execution	[Kn18]		●		
30	Elicit processes through wearable sensors	[Ra18]		●		
31	Real-time modelling tool with the usage of Smart Glasses, a first-person view video recorded by the Smart Glasses is used as an input to create augmented reality-based manuals	[PPS13]	(●)	●		
32	Event-based data from software is analyzed and interpreted into process models	[CW98]	●	●		
	Legend: ● concept is directly fulfilled (●) concept is indirectly fulfilled					

Tab. 1: Concept Matrix of Technology-based Process Elicitation Techniques in accordance with Webster and Watson [WW02]

(IV) Process elicitation techniques in Workshops: Process elicitation has a strong relationship with workshop sessions, 12 out of 32 papers link process elicitation with workshops. Especially the following process elicitation approaches are mainly represented: (Story)telling and digital tools. For instance, Simões et al. [SAC18] revealed that storytelling has a positive effect on process elicitation.

3.2 Taxonomy for Technology-based Process Elicitation Techniques

We followed the method for taxonomy development by Nickerson et al. [NVM13] (cf. Figure 3) to create the taxonomy for technology-based process elicitation techniques. First, the implied meta-characteristic defines the objects that are interested in the developed taxonomy. These are solely technology-based process elicitation techniques such as referred in the concept matrix (cf. Table 1). The ending condition contains the basic definition of a taxonomy, i.e. dimensions with mutually exclusive and comprehensive characteristics [NVM13].

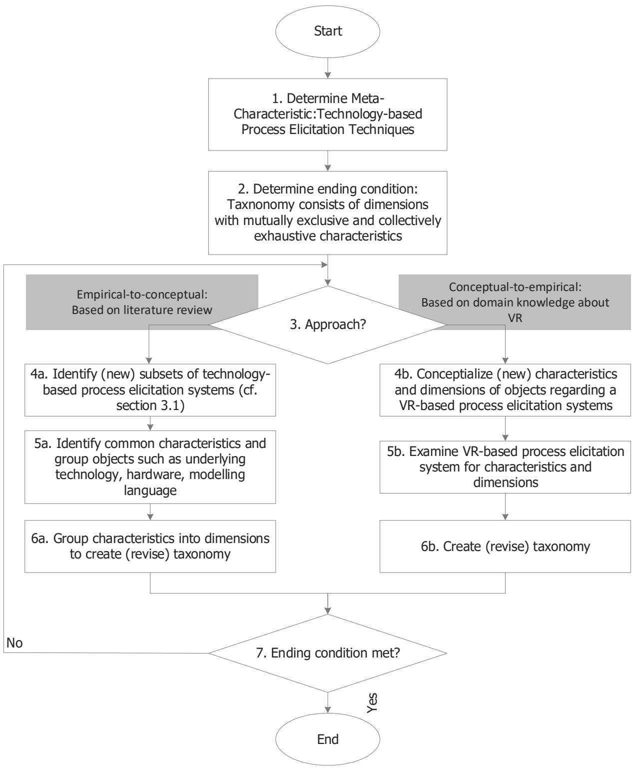

Fig. 3: Applied taxonomy development method in accordance with Nickerson et al. [NVM13]

We first undertake the empirical-to-conceptual approach based on the findings of the literature review and performed steps 4a, 5a and 6a with several iterations till the ending condition was met. Afterwards, we supplemented dimensions and characteristics by carrying out the conceptual-to-empirical approach with the steps 4b, 5b and 6b. In these steps, we integrated technology knowledge about today's VR hardware that is hitherto not reflected by technology-based process elicitation techniques in the literature. This procedure leads to the following taxonomy depicted in Table 2.

<table>
<tr><th>Dimension Class</th><th>Dimension</th><th colspan="12">Characteristic</th></tr>
<tr><td rowspan="2">Human</td><td rowspan="2">Communication</td><td colspan="6">Workshop</td><td colspan="6">Digital Collaborative</td></tr>
<tr><td colspan="6">Face to Face</td><td colspan="6">Alone</td></tr>
<tr><td rowspan="8">Computer</td><td rowspan="4">Technology-based elicitation technique</td><td colspan="4">Story(telling)</td><td colspan="4">Interview</td><td colspan="4">Virtual World / Reality</td></tr>
<tr><td colspan="4">Sketch</td><td colspan="4">Event Log</td><td colspan="4">Workshop</td></tr>
<tr><td colspan="4">Camera</td><td colspan="4">(Modelling) Tool</td><td colspan="4">Semantic Wiki</td></tr>
<tr><td colspan="4">360-degree Recording</td><td colspan="4">Text Mining</td><td colspan="4">Mobile Application</td></tr>
<tr><td rowspan="4">Device</td><td colspan="6">Desktop</td><td colspan="6">Smartphone</td></tr>
<tr><td colspan="6">Tablet</td><td colspan="6">Multi-touch Table</td></tr>
<tr><td colspan="6">Smart Glasses</td><td colspan="6">VR Headset</td></tr>
<tr><td colspan="6">Wearable</td><td colspan="6">Sensor</td></tr>
<tr><td rowspan="2">Interaction</td><td>Modelling elements</td><td colspan="4">Standardized modelling elements</td><td colspan="4">Domain-specific modelling elements</td><td colspan="4">No modelling elements</td></tr>
<tr><td>Transformation of elicitation knowledge into a process model</td><td colspan="3">Direct</td><td colspan="3">Text-mining</td><td colspan="3">Activity Recognition</td><td colspan="3">Workshop Facilitator</td></tr>
</table>

Tab. 2: Taxonomy for Technology-based Process Elicitation Techniques

We defined three dimension classes that are oriented on human-computer-interaction systems due to technology-based process elicitation systems can be sorted into them as subsystems. The first dimension classifies what kind of communications are involved during the process elicitation phase. The next dimension consists of technology-based elicitation techniques that are identified in the literature review and are supplemented with characteristics from the VR domain. The third dimension classifies the device to elicit the processes. The fourth dimension includes if a modelling language is applied during the elicitation. As already mentioned in 75 % of the identified literature a process modelling environment is integrated to elicit processes. Finally, the last dimension classifies how the transformation of the elicited knowledge into a process model will be achieved. The in grey highlighted values are covered by the VR-based process elicitation system. Although the marked characteristics are not exclusive, they represent different statuses within the VR-based process elicitation system (cf. section 4).

4 Designing a VR-based Process Elicitation System

4.1 Objectives of a VR-based Process Elicitation System

Based on insights of VR and the affiliated problem, we state objectives of the VR-based process elicitation system. The recall ability of information by process modelling users should be increased due to the direct visualization of the elicited process environment.

Furthermore, modelling activities should be simplified. This is achieved by a reduction of process notation elements for tasks, events and organizational units and an easy selection within VR. Moreover, novice process modelling users should learn a process modelling language faster due to the direct visual connection between the real world and the process notation elements. Lastly, discussions within a process modelling workshop can be enhanced. This is realized due to a minimized language barrier explained by visualization. Also, discussions about global processes could be more efficient due to the reflection of globally distributed business locations by using 360-degree recordings.

4.2 Requirements and Architecture

We identified important concepts based on the literature review that is in our point of view applicable for a VR-based process elicitation system. The proposed architecture is shown in Figure 4. We suggest the usage of a domain-specific modelling language (DSML) to annotate tacit knowledge in 360-degree panorama recordings [SC15] with the VR system. The DSML should represent different tasks, information or events. A similar approach is done in [Br14] by augmenting knowledge in 3D virtual worlds. Here virtual worlds facing the problem that they have to be modelled and programmed. In our point of view, the associated costs are not justified and are not in proportion to the generated benefit. Hence, we propose the usage of 360-degree panorama recordings that can be generated easier and are related to fewer staff costs. A 360-degree panorama recording is taken by a 360-degree camera that is able to shot the whole surrounding with one shot. In combination with this concept is the use of computer vision to recognize specific objects and to receive automatically generated modelling recommendations. A further developed gesture recognition system enables the functionality to draw specific signs into the 360-degree recording. Therefore, additional input sensors such as the Leap Motion Controller can be used to identify detailed hand gestures [BWR18]. For instance, a drawn triangle creates a warning sign. Besides the controller input, the domain expert can use voice to assign longer process knowledge in the VR environment. A voice recognition subsystem transfers the speech into text and a text mining approach such as in [DSB09] could identify process elements. A basic user authorization leads to a proper assignment of released 360-degree recordings. Finally, a transformation system interprets the created annotations (drawings, voice annotations, logs) in the 360-degree recordings and generates semi-formal process models that is similar to the realized IMPROVE process modeler by Leinenbach [Le00].

The main components such as 360-degree recordings, VR hardware system, and the previously described VR-based process elicitation system are mandatory. The system can be optionally extended by a live view, a desktop-based process modelling environment, and a smartphone application to retrieve recommendations (covered in blue) to include a modelling component. By the extension, the system can be integrated into modelling workshops and interlinks the modelling facilitator who can design the semi-formal models with the desktop-based modelling system. Workshop participants can see the actual VR environment by the live view. Furthermore, they can send recommendations via smartphone to the domain expert who is situated in the VR environment. Moreover, we want to consider the seven design principles for tools that facilitate participatory modelling sessions [Lü11] for the development of the VR-based system. The proposed architecture has strengths and weaknesses. On the one hand, many integrated subsystems make the system applicable for different use cases. On the other hand, increased implementation efforts are related to them. The usage of 360-degree recordings and a user authorizations system allows the system to become a scalable public available web-based system assuming that it is hosted in the cloud. Users solely have to upload their 360-degree recordings and can use the system. By this approach, the development costs can be shared with the entire users and as a result the system will be more cost-efficient.

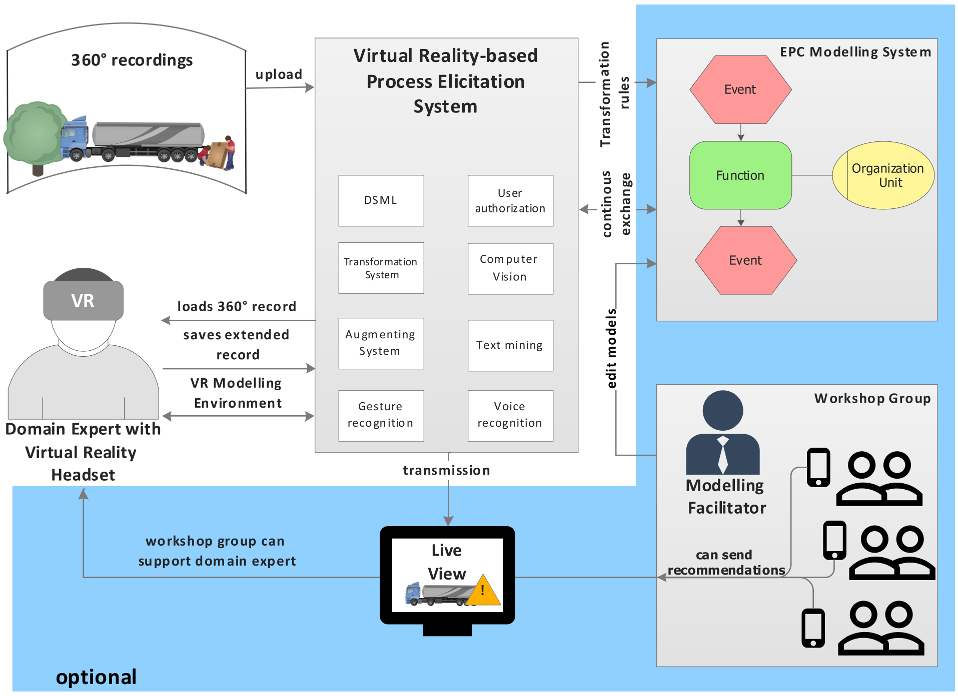

Fig. 4: Architecture for the Virtual Reality-based Process Elicitation System

5 Discussion, Limitations, and Conclusion

5.1 Discussion and Limitations

The design science-oriented research project is subjected to certain limitations. Firstly, an overall check if VR is suitable to elicit processes was not done. Predominantly VR is mainly used in domains such as the gaming industry or for planning and design e.g. architecture. Although associated co-existing work with virtual worlds exists and usage is therefore not new, it has to be discovered if a process elicitation with VR is appropriate in terms of usability. Factors that could negatively affect the usability are the added complexity and the high-tech feel due to VR headset and controllers that hinder or distract users. Further investigations have to be taken regarding what kind of processes are suited to be represented in VR.

The evolved architecture was developed based on empirical insights from the literature review. However, it remains in a subjective point of view by the authors. Therefore, the architecture has to be discussed and validated during the requirements elicitation phase in the future. Moreover, the presented architecture represents only a rough representation. Additionally, proposed subsystems and concepts have to be designed in detail in future studies. The same applies to the derived taxonomy for technology-based process elicitations systems. Moreover, extensive insights will be achieved during the design and development phase with a first implemented proof of concept and demonstration in a process modelling workshop. At this time the suspected advantages of the proposed solution in particular for novice modelling users can be validated, i.e. better recall ability, easier process elicitation, elicitation of globally distributed processes, minimizing language barriers and faster learning of process modelling notations.

5.2 Conclusion

This paper presents a new research direction that is based on previous work in the domain of technological-based process elicitation techniques. The groundwork delivering 32 identified papers by means of a conducted systematic literature review. A VR-based process elicitation system with the integration of today’s VR hardware in combination with 360-degree recordings should improve the elicitation of processes, especially for non-modelling experts. The presented elicitation approach can be used in a single, collaborative and workshop environment. Thereby, it is broadly applicable and provides to the best of our knowledge the first time a proposal, by means of architecture, to integrate today’s VR 360-degree hardware standards into an elicitation system. In doing so, the system should be in favor to elicit processes that are globally distributed and simplify the process elicitation for novice modelling users due to visualization and immersion. Further research steps are the elicitation of additional requirements with quantitative and qualitative studies. Based on the requirements a runnable prototype has to be developed that delivers the first proof of concept. Then, supplementary evaluation studies reveal improvement possibilities.

6 Acknowledgements

This research is funded by the "Graduiertenkolleg va-eva: Vertrauen und Akzeptanz in erweiterten und virtuellen Arbeitswelten" at the University of Osnabrueck. We would like to thank them for their support.

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