How to elicit user requirements for innovative future technology:
Creating and evaluating a new elicitation method in the context of highly automated driving

Objectives: Taking the user into account during the whole lifecycle is an essential part of Requirements Engineering (RE) (Vavoula et al., n.d.). Otherwise, the design would not fit the users' vision and lead to difficulties using the products (Robertson, 2001). Therefore, in the beginning of a design lifecycle, requirements elicitation is an important step that takes users' opinions into consideration and focusses on their wishes. The difficulty arises how to let the user engage and experience a future he/she has not even thought of in a context that does not even exist. The challenge of how to extract user requirements from dreams evolves (Boehner et al., n.d.). Therefore, the research question was established how user requirements can be elicited in an innovative future oriented context.

Method: Based on a literature overview and evaluation criteria (specific for the innovative future oriented context) a method was established that is suitable for requirements elicitation. The established method of future workshops consists of three different parts. A pre-phase containing different studies (diary study, steering zone study) was based on material applied in the workshop on the users' level. The method was iteratively evaluated and further developed. The improved version was used to hold two workshops that were each focussed on a specific user group (elderly, mass-market).

Results: The data retrieved in the different phases could be structured in three main categories (general/technical, HMI, steering gestures). Furthermore, scenarios were derived from the workshop. Per workshop two concepts were developed that are described based on the presentations given by the participants and their paper-prototypes.

Conclusion: In general, it can be concluded that the goal to establish a method that elicits user requirements in an innovative future oriented context has partly been reached. General requirements could be elicited that were directed towards a future context, but innovative ideas contradicted and did not fit the traditional perspective of user requirements. Moreover, further research is needed that evaluates adaptions to the prototyping phase. To sum up, the developed method forms a starting point for further research in different contexts and the evaluation of adaptions.

Over the last few years more and more innovations in technology have taken place that are focussed on applications in a 'far future' (Cagnin, 2008). An example of these kinds of future innovative systems is the concept of highly automated cars and the challenges that they entail. A great number of these challenges stem from human factor related issues (Akamatsu, Green, & Bengler, 2013). Challenges might occur when users' expectations are not met and users are unable to relate to the system or accept it (Arndt, 2011). Therefore, it seems to be important to introduce the users as early as possible to the process. A design lifecycle that involves users in every step seems to be important (as stated by the participatory design method) (Vavoula & Sharples, 2007). By giving users the chance to pass their judgement and state their wishes and also to reveal the challenges they expect a system to have, the new technology can be adapted in the eyes of the users' requirements. Otherwise, a new innovative system could lack essential requirements the users would have wished for. This might then resolve in users not accepting technology and other usability issues (Arndt, 2011).

To fit the users' expectations and engage them in the design lifecycle from the beginning in the area of requirements engineering (RE) provides a variety of methods and tools when it comes to user requirements. Each phase of the RE process is thoroughly studied and seems to offer a suitable range of different techniques for every context (Zowghi & Coulin, 2005). For example, interviews can be used to elicit user requirements. This user requirements elicitation phase forms an essential basis for the end product. But there seems to be one specific challenge when it comes to requirements elicitation for innovative technology. With innovative new technology that is not yet implemented, it becomes more and more difficult to apply a suitable method. Users are not aware of their wishes, because they relate to systems they have not even thought about yet (Robertson, 2001).

In order to elicit user requirements properly the user needs to be involved in the design lifecycle. But many methods stay at the level of only 'talking about' the product rather than really letting the users interact and engage with the new innovative systems (Bargas-Avila & Hornbæk, 2011; Vavoula & Sharples, 2007). In the context of highly automated driving, the task of eliciting user requirements might first seem feasible due to the variety of methods that are offered. But established methods such as interviews fail to let users interact and directly engage with the system. Without any kind of introduction or experience it might not be possible for the user to imagine what a system could even look like. Users might then indicate general requirements but the elicitation process would stay at this superficial level (Vavoula, Sharples, & Rudman, n.d.).

In general, it can be concluded that RE seems to be an acknowledged approach but regarding the context of innovative future technology, there are still challenges that need to be solved. Users need to imagine future innovations that are not yet implemented and are therefore restricted by the limits of their experiences. The bridging between current experience and future technologies is needed to provoke an innovative process. Users need to be engaged to be completely involved in the lifecycle. But future technologies are not only not yet implemented but are also far too abstract and not comprehensible to simply let users engage with them. The statement still remains true that 'the choice of method must always be related to the situation at hand and the people involved' (Löwgren & Stolterman, 1999, p.14). This challenge for a future oriented context still remains to be solved.

The context of highly automated driving can be applied to try to solve the challenge mentioned above. This technology provides a platform that combines innovativeness with a technology that is intended to be applied in the future. In addition, this area provides a variety of challenges in the human factors area on its own that still need to be solved (Akamatsu et al., 2013).

According to Parasuraman & Riley (1997) automation takes place, when tasks and functions are executed by a machine which were previously carried out by a human. According to Akamatsu et al. (2013) there still exists a variety of human factors related challenges when it comes to automated driving. One main issue is the interaction between the system automation and drivers. If a system is able to take over certain driving tasks and can for some parts act individually, it seems as if the driver has the freedom to occupy with other tasks that are not driving related. However, if the system reaches its boundaries and demands the driver to take over control again the driver needs time to become aware of the situation again (situation awareness). At least 12-15 seconds are needed for the driver to be back in the loop (Vogelpohl, Vollrath, Kühn, Hummel, & Gehlert, 2016). Some situations demand the driver to stay attentive the whole time and be in the loop (e.g. road work scenarios). It seems to be important to keep drivers in the loop. Otherwise difficulties such as mode confusion or consequences due to the driver being out of the loop may lead to risk and restrain safety in major ways (Akamatsu et al., 2013).

The question arises what automation means in this context and how it is transferred. An automated system can vary from manual to fully automated. Possible levels could then be

assisted/lowly automated, semi-automated, highly automated (in the loop) and fully automated (partly out of the loop).
The vehicle might then for example drive partly autonomously but the driver is always kept in the loop to be able to take over control. This control can be characterized as having the power to influence a situation. This implies that the driver is still able to influence the situation which relates to a high level of responsibility. If the driver needs to be responsible during higher levels of automation while being out of the loop, there seems to be the question who is actually in control/responsible. One solution could be to focus on manual driving so the driver holds the full responsibility. But automated systems have the power to enhance safety and comfort and should therefore not be disregarded (Howard & Dai, 2014). Neither manual driving nor full automated driving seems to perform well.

The h-mode tries to provide an opportunity to integrate the lessons that have been learned regarding human-centred automation. It has proven to offer a solution that combines high levels of automation and knowledge acquired regarding interaction between humans and automation (Flemisch, Kelsch, Löper, Schieben, & Schindler, 2008). The cooperation between driver and automated system in the h-mode focuses on always keeping the driver in the loop.

A possible solution for this challenge could be a cooperative control. When sharing the control between the automation and the driver on varying levels, a safe interaction could be provided. This cooperative interaction can be described with the H(orse)-metaphor and is implemented with the h-mode. The H(orse)-metaphor describes a concept of an intuitive cooperation, interaction and communication between a horse and its rider that is transferred to the interaction between an automated system (e.g. in a car) and the driver. The h-mode focusses hereby on a haptic-multimodal connection between the driver and the automated system. Most of the time the h-mode is used in the context of active interface devices such as active pedals, steering wheels and active side sticks. All of those modalities are able to provide the driver with force and/or position feedback (Flemisch et al., 2008).

As described above the h-mode also relates to the different levels in the automation scale. These different levels/modes illustrate a dynamic distribution of control that characterizes the h-mode. The transition between these modes is fluid. A naturalistic transition could for example be that the drivers loosens his/her grip on the active inceptor and thereby signalizes the transfer of control to the automation. This example equals the transition from tight to loose rein. If the driver keeps his/her hands completely away from the active inceptor this could signalize the secured rein mode. To take over control again the driver can impose his/her hands on the active inceptor and furthermore increase his/her grip to signify the severe role of control.

As stated above these levels are depicted as ‘tight rein’ (horse is fully controlled and limited by the rider) relating to assisted automated level. In this mode the control lies mainly with the driver and the automation functions as an assistance (only low forces on haptic active interface). In the ‘loose rein’ (horse can act more independently and is no longer strictly controlled due to slackly held reins) the role of the automation increases. The driver is still in the loop and connected with the vehicle (haptic coupling with active interface). Later on, a third mode was added to the concept, the ‘secured rein’. This mode indicates that the vehicle is highly automated and the driver is partly out of the loop (Flemisch et al., 2008). This secured rein can be found in the context of working horses where the reins are secured to enable the person to act freehand.

The design goal of the project described above is a haptic-multimodal gesture control that applies the h-mode described above as well as that it can be used by different user groups (average, young, disabled, and elderly). The final design should be adaptive to their different requirements. That means that depending on the elicited user requirements, a different variety of design aspects can be applied. To achieve this goal, requirements need to be established that can serve as a base for possible design solutions/ideas. In order to come up with a solution that fully represents the end user, all user groups need to be part of the research from early on (Robertson, 2001).

As described above, the innovative and future oriented context of automated driving challenges the approach of requirements engineering. If data is acquired by using traditional methods, the results might not be valid because they account for wishes that originated from a misconceived perspective that lacks experience with the new technology (Inkpen, n.d.). This might not be noticeable during the progression and development of a prototype, but later on during the evaluation of the product. The acceptance might suffer due to this missing experience (Arndt, 2011).

The study that is going to be performed consists of different parts. The first part focusses on seeking out the most suitable method for user requirements elicitation in context of the project framework. That is the reason why the first step of this study is going to be the development of a suitable method. This method should elicit user requirements for a future system in the context of the project.

Therefore, a literature review will be executed to give an overview on different methods of requirements elicitation. Advantages and disadvantages are presented with every method to facilitate a later judgement. Based on the context of the project criteria will be established to support the assessment of the different techniques. The different methods will then be evaluated based on the established criteria. Based on these results a concept will be established that combines and/or adapts a suitable method for requirement elicitation for future technology.

In the second part of the study the method is tested and iteratively evaluated and improved further. This iterative process can assure that users are sufficiently integrated and the method is based on their standpoint of experience and knowledge of the topic. After preparation and planning of the new method, the method is used with two different user groups (elderly, mass market). Based on the established method the acquired data is then further analysed to evaluate the performance of the newly designed approach.

As described above the goal is to establish a method for innovative future technology to elicit user requirements. Therefore, the research question was established:

'How to elicit user requirements for innovative future technology?'

Based on a rating of different RE methods (as described above), evaluation and information gathered of application, a future workshop seemed to be the most suitable method. This method will be further developed. Therefore, adaptions as well as other additional methods and steps are included. The original method of future workshop consists of three phases. In order to keep the workshop short and efficient, the three main phases should be maintained. In the used context, the seven phases used in the Vavoula & Sharples (2007) study would demand too much time from the participants. Moreover, the preparation would not be time efficient. Some phases of the future technology workshop are shortened to only 15 minutes (e.g. Imagineering). It is important to capture every idea developed during the workshop. Therefore, discussions and presentations of the results should not be limited as they might be essential for ideation. A combination that integrates the most suitable phases and techniques of the original version and the adapted version created by Ihlström et al. (n.d.) seems to be suitable. Based on these considerations the future workshop depicted in figure three was developed.

The overall method that will be used in this study consists of different parts and iterations. First, a general study on steering gestures will be performed. This study can be useful to gain insight in users' perspective towards the topic 'steering gestures' in general as well as evaluating key questions and use cases. These use cases as well as current driving experiences can also be extracted via a diary study. To evaluate the diary study, an iteration with a pilot version will be carried out. A pilot study is used to assure that the new methods will be able to fulfil the goals in a realistic setting. When creating and adapting new methods it seems to be essential to test them out to iteratively develop the most suitable method. As there are no indications in literature on the performance (it is only possible to deduce and assume from similar studies) of the method, it is important to acquire knowledge on how long the workshops will take and what general issues need to be adapted. These pilot studies are then followed by the actual studies (e.g. diary study and future workshop).

The studies mentioned above all elicit material that is used as a base for the future workshops (described above). By using material directly from user groups, a more grounded base of the workshops can be assured that matches their current perspective. In order to be able to evaluate the strategies and techniques used in the workshop a pilot study will be performed. This iteration provides the option to improve the workshop further (Nielsen, 1993). The improved version was used to hold two workshops that were each focussed on a specific user group (elderly, mass-market).

The results acquired during the workshop elucidate that this focus on the users' perspective is a prominent aspect. In general, the results were based on steering gestures that focussed on a cooperative interaction with the system. During the visioning and fantasy phase the participants developed possible wishes and requirements they would have towards a future system, but also reflected on challenges that could be related to the system. In addition, a variety of scenarios in which the participants would wish a system to assist them were given. In the last phase four different concepts were established that each presented an individual vision of steering gestures focused on a cooperative interaction.

In general, it can be concluded that the goal to establish a method that elicits user requirements in an innovative future oriented context was partly reached. General requirements could be elicited that where directed towards a future context, but innovative ideas contradicted and did not fit the traditional perspective of user requirements. Other approaches such as a design space are needed to relate users' ideas and statements to a fitting format. Moreover, further research is needed that evaluates adaptions to the prototyping phase. Although, heterogeneous groups seemed to be not efficient (due to limited time) regarding the goal of prototyping a concept, the diversity of groups still is essential to create innovativeness (Brown & Wyatt, 2010). Therefore, an adapted version of the last phase is needed while still using the other phases that form a base for the later on implementation. The first two phases seemed to work sufficiently in this context. Still there is the issue of the need for adaption when applied in different contexts. The preparation for the trigger part and also the general user centred perspective is time consuming but essential and should not be disregarded. The method seemed to be applicable for the context it was used in, but should also be tested for different innovative directions. To sum up, the developed method worked and can probably be adapted to a wider class of future-oriented design projects. Major improvements can possibly be reached by a recombination with other UX methods, such as personas and design thinking.