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Advanced Design Project

Advancement and Prototyping of a Driver Interaction System for Simulated Test Drives

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Declaration

I hereby declare that I have written the submitted thesis independently without any outside support except for the quoted literature and other sources mentioned in the thesis. All the thoughts acquired and employed, directly or indirectly, from any foreign source are clearly identified and listed in the thesis. This work has neither been handed in nor published in the same or similar form before.

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Abstract

A monotonous environment during driving on long highways can lead to a dangerous state of drowsiness of the driver. The previous advanced design project (ADP) of Amini et al. developed a concept of a driving assistant system, which uses gamification features to break the monotony of the driving task. This work picks up this concept and develops a software prototype of an interface to perform *wizard of Oz*-experiments in the driving simulator of the institute for ergonomics (IAD) at the Technical University Darmstadt. The development processes due to the guidelines of the human centred design process. The context of use for the prototype must be seen through the perspective of the driver as well as through the perspective of the experimenter. The driver is in a monotonous driving environment and can get input by head-up display (HUD), liquid crystal display (LCD) or audio output. The experimenter can monitor data about the current driving behaviour given by the simulator software. In addition, the experimenter uses the prototype on a laptop. The requirements for the development are derived from ISO 9241-110. The developed prototype is an interface between driver and assistant as well as an interface between experimenter and assistant system. A user of the prototype can control the three output channels with the software prototype. The user sees the content of HUD, LCD and has a control panel with buttons which enables him to handle his task. In contrast to this, the driver can only see the parts of the interface showed via the HUD and the LCD. The screen content of the wizard interface is shared with the software *screenleap and teamviewer* with a smartphone in front of the windscreen, which represents the HUD and with a tablet, which represents the LCD on the middle console of the car. Therefore, it is possible to show the corresponding parts of the interface to the driver. It is possible for the driver to interact with the assistant system by voice. A start procedure, a quiz and three driving games, which motivate the driver to show a better driving behaviour, are the main features of the prototype. The games challenge the driver to hold the current speed or to hold the current distance to the vehicle in front or to exactly hold the position in the middle of the driving lane for 60 seconds. The task of the experimenter is to rate the behaviour of the driver during the games and transfer this input to the assistant system. Buttons to rate the behaviour and to create a score are included into the interface of the experimenter. Depending on the score, the driver receives a feedback of his current performance by the HUD and afterwards a feedback about his performance over the complete duration of the game. Furthermore, the experimenter can handle scenarios, which pause the game e.g. lane changes or dangerous situations like emergency stops. Next to the driving games, a quiz is implemented into the prototype. The quiz and the starting procedure are created as an oral dialogue between driver and assistant system. To trigger the corresponding audio output, the experimenter has different buttons, which suit for the current situation.

The usability of the prototype for the experimenter is evaluated in this paper. Afterwards small changes will be considered to improve the usability. The developed prototype allows to perform *wizard of Oz* experiments in the context of the IAD driving simulator. Only these experiments can show if the concept of an assistant system, which uses the described gamification features are suitable for a driving scenario with other road users and if such an assistant system can reduce the monotony of the driver.

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1 Introduction

1.1 Motivation

Sleep related road accidents are a permanent danger for driver and their environment. A study by Horne & Reyner, 2001, performed in U.K., shows that sleep related accidents make up to approx. 15-20% of all accidents in which the police is called Horne & Reyner, 2001. Other researchers validate the number even though drowsiness as a cause is more difficult to prove than other causes as drugs and alcohol. However, drowsiness causes more accidents then the consumption of drugs and alcohol (Akerstedt & Wright, 2009). Therefore, a need to decrease the probability of a sleep related accident is a priority topic not only in the automotive industry but also in research. Another study examined in Bavaria shows that at least 24% of the accidents are due sleep related causes (Langwieder, Sporner, & Hell, 1994). Indian studies on sleep related accidents can not be found. However, general statistics show that in India road traffic injuries are the sixth highest cause of death. Among the causes, human factors share a large part of 77,5% in 2007 of all road accidents of which drunk-driving but also drowsiness are major cause factors (Ruikar, 2013).

Not all of the sleep related road accidents are due to sleep deprivation but rather due to work related fatigue. The drivers overestimate their driving ability while driving in a drowsy state. They keep on driving even though they are aware of their drowsiness and the danger of driving in a drowsy state (Nordbakke & Sagberg, 2007). Therefore, the automotive sector recently introduced driving assistant systems to encounter the danger related to drowsiness. However, up to date the driving assistant systems provided by the automobile companies only help detecting drowsiness and inform the driver about his drowsy condition. Thus, other actions than to recommend sleep or to drink a coffee are not available in current systems. The driving assistant systems lack the ability to encounter the driver's drowsiness by reducing it or maintaining his vigilance.

In the presented thesis, a gamified concept of the driving task by introducing a secondary task to the driver is implemented into a prototype to perform *wizard of Oz*-experiments. The concept of the prototype contains a virtual co-driver and game features. The prototype may help the driver to maintain his vigilance and reduces the monotony of driving on highways.

1.2 Purpose of this thesis

In the course of previous advanced research project (ARP) by Hieronymus, Post, Schwab, & Thiele, literature about the influence of drowsiness in road traffic was investigated and summarised and a first concept of an assistant system, which supports the driver in monotonous situations to beware him from drowsiness, was developed. The work of the previous ADP by Amini et al., 2016 built up on this concept, refined it and developed a prototype of a driving assistant system based on a click dummy. There are two central elements, which are also found in this thesis. The concept is based on the idea to create an assistant system that acts as a virtual co-driver and includes gamification features to maintain the interest of the driver into the driving topic.

To perform first test rows with this concept in the driving simulator of IAD, a connection between the behaviour of the test person in the driving simulator and the actions of the virtual co-driver is strictly necessary. An implementation in the driving simulator's environment is cost intensive and time consuming, besides being a complex project. The presented prototype allows to analyse the influence of a gamified driving assistance system in *a wizard of Oz* environment. Therefore, condition for a *wizard of Oz* experiment must be developed. Consequently, every interaction between virtual co-driver and test driver is controlled by the "wizard" in the background.

The purpose of this thesis is the development of a software prototype to perform a *wizard of Oz*-experiment in the driving simulator of the IAD. Next to its development, a concept is created to integrate the prototype into the driving simulator of IAD.

1.3 Structure of this thesis

The theoretical principles of the study, including definitions of the terms *drowsiness* and *gamification* in the context of driving, are presented in chapter 2. Referring to the work of Hieronymus et al., Amini et al., and the research, which will be outlined in chapter 2, the concept of this project is explained in chapter 3. Afterwards, the analysis of the user context and the derivation of requirement is documented in chapter 4. Chapter 5 contains the presentation and explanation of the developed software prototype including all features. The prototype is evaluated, which is documented in chapter 6. Furthermore, the iterations, which were processed in the prototype on the basis of the evaluation, are shown.

Finally, the project is summarized in chapter 7. Additionally, the perspectives of working with the developed prototype in the future are pointed out.

2 Theoretical principles

The following chapter briefly introduces the basic design of the prototype, which is developed in this project. Firstly, the term *drowsiness* and the related term *vigilance* will be explained. Causes of drowsiness and challenges are discussed. The chapter *gamification* helps to understand the game design process and the relevance in the context of the driving scenario. The presented thesis is based on the human centred design process, which will be briefly explained. Subsequently, the experimental environment in which the prototype will be used is described as well as the software used to develop the prototype.

2.1 Drowsiness in road traffic

Drowsiness in driving situations is a major cause for accidents especially on highways. Even though drivers are aware of its risk potential, the effect of drowsiness is usually underestimated. In the following, important definitions related to drowsiness are briefly explained. Furthermore, the cause and challenges regarding drowsiness are investigated. Finally, the influence of a co-driver is examined.

2.1.1 Terminology

The term *drowsiness* refers to a state of exhaustion, high arousal and a lack of concentration (Greschner, 2011). It is to distinguish from the term *fatigue* which describes the overall exhaustion while in the state of drowsiness a desire to sleep is active. According to Schlick, Luczak, & Bruder, drowsiness occurs due to an imbalance of supply and use of resources. These resources can either be psychological or physiological. Furthermore, drowsiness can occur due to different other factors. When the use of resources is higher than the supply, present resources are used. This leads to a decrease of responsiveness. Hence, constant workload tends to result in increased effort causing fatigue (Schlick et al., 2010). However, a workload does not necessarily lead to fatigue. Moreover, the same workload can lead to different extent of effort depending on the available resources. Thus, the terms *workload* and *effort* have to be clearly separated. While the term *workload* refers to the difficulty of a task, the term *effort* considers the available resources and the structure of the task. The relationships of *workload*, *effort* and *performance* are U-shaped in the case of *workload* and *effort* and upside down U-shaped in the case of *workload* and *performance*. As a result, an excessive demand, as well as too low demand can lead to underperformance, whereas only a medium demand leads to an optimal performance as shown in Figure 2.1 (Schlag & Weller, 2015), (Waard, 1996).

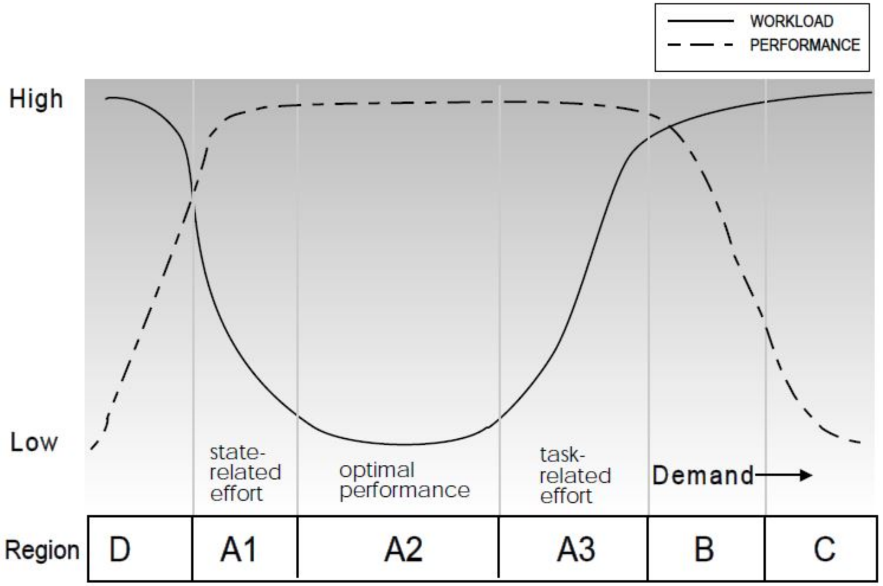


Figure 2.1: Relationship of workload, performance and demand (Waard, 1996)

For the case of too low demand the term *vigilance* is used. *Vigilance* describes the responsiveness to random impulses in monotone situations. It is used to specify the attentiveness and the decrease of the vigilance is a result of a task related process (Greschner, 2011). It occurs under long and unchallenging tasks. The state of low vigilance can be disrupted immediately by replacing the task, changing the environment, bringing the driver in an alarming state, giving him with new information or by causing an affective change (Schlick et al., 2010).

2.1.2 Cause of drowsiness

Causes for drowsiness can be subdivided into two different categories, the sleep related drowsiness and the task related drowsiness. Sleep related drowsiness describes the difficulty to stay awake due to a lack of sleep and is related to the circadian rhythm. It can only be reduced by sleep; a rest does not help. Task related drowsiness is influenced by external factors and can be subdivided into passive and active task related drowsiness. While the passive task related drowsiness occurs in monotone situations with low workload and high predictability, active task related drowsiness occurs in situations with high workload. In comparison to sleep related drowsiness, task related drowsiness can be reduced by resting. (Schmidt, 2010)
In the present thesis, drowsiness due to task related factors is analyzed. The task related drowsiness occurs due a monotone and therefore unchallenging driving situation. Monotone driving situations appear on highways with low dense traffic (Greschner, 2011). Moreover, a monotone driving situation is characterized by a constant acoustic level and low visual stimuli. The lack of stimuli results in decrease of responsiveness. According to (Greschner, 2011) monotony can be caused by:

- long, repetitive or monotone activities
- short cycle duration of repetitive activities
- short learning time
- social isolation
- few possibilities of body movement
- dark environment

Most of the causes listed can be found in highways with low dense traffic especially during the night. Little changes in the environment with a repetitive task lead to drowsiness and a higher chance of sleep related accidents.

2.1.3 Challenges regarding drowsiness

Even though most drivers are aware of the fact that sleeping or taking a nap can help to reduce drowsiness, most of them do not use these countermeasures to reduce their drowsiness (Nordbakke & Sagberg, 2007). Nordbakke and Sagberg examined a study about the drivers' knowledge of their sleepiness in relation to their action. They found that most drivers continue to drive even though they are sleepy. Rather than taking a nap or getting out of the car the drivers take different measures, such as playing loud music or drinking coffee. However, it is to mention that most drivers are aware of sleep related accidents but underestimate the danger during daytime. They believe that least sleep related accidents occur during daytime as well as that they overestimated their actual driving ability under the state of drowsiness. For the symptoms, the most important ones are frequent yawning and the difficulty to keep their eye open. (Nordbakke & Sagberg, 2007)
However, there are further symptoms drivers do not notice. The drivers' drowsiness leads to misjudgment of distance, velocity and many more (Rogé, Pébayle, Hannachi, & Muzet, 2003). More fatal than the symptoms are that the driver does not realize that he is sleeping. It is an unconscious action and hence, only a nap of 15-20 min is a useful countermeasure to reduce drowsiness and hereby the probability of a sleep related accident (Horne & Reyner, 2001, 2001).
Furthermore, the monotonous driving situation on the highway is enhanced by technological advances. In modern vehicles, the driving assistance system facilitates the driving task as well as automatic gears. On highways, a speedometer can hold the speed without an interaction from the driver (Greschner, 2011). Greschner fairly stated that for the driving situation the reduction of monotony is a challenging task. The goal of the project is to reduce monotony and hence, drowsiness by reorganizing the driving task.

Therefore, a gamification design is incorporated in the driving task. The motivation is to increase the vigilance by compensating low stimuli with artificial stimuli to help the driver focus on driving.

2.1.4 Role of Co-Driver

The concept of this driving assistant system against monotone driving situations is linked with the idea of having a passenger in your car. A passenger can positively contribute to the driving behavior of the driver. However, a positive contribution is dependent of the behavior of the passenger as he can also have a negative influence on the driver. In the following the influence of having a passenger in a car is explained.

In various studies the relationship of the passenger on the driving behavior of the driver is illustrated from different perspectives. The driver tends to drive more slowly and with more distance to the next car when a passenger is in his or her car. But at the same time the minor inaccuracies appear. Moreover, many studies show that the overall risk of a vehicle accident is lower with a passenger. However, the results are highly dependent from the age and sex of the driver and the passenger. Especially young, male drivers with passengers of the same age have a higher risk of an accident because they try to show off their driving ability and do risky maneuver. (Ellinghaus & Schlag, 2001), (Maciej, 2012) Engström, Gregersen, Granström, & Nyberg, performed a study on the influence of passengers in a vehicle on the accident risk of the driver. The study aims to explain the influence of the number of passengers on the accident risk of drivers of different age groups as well the influence of gender. One of the study's results is that the presence of a passenger decreases the accident risk for all age groups and the accident risk decreases with every additional passenger. Moreover, the decrease of the accident risk due to the presence of a passenger is independent of gender. However, the effect is stronger for the female gender. The authors' conclusions for the influence of the passenger on the accident risk are that the driver has responsibility for the passenger and hence drives more safely. Furthermore, the driver tends to drive better to impress the passengers with good driving skills. However, the definition of good driving skills is dependent of the age group of the passenger. Therefore, young drivers tend to drive carefully when the passenger are children or older, while they tend to drive riskier when the passenger is of the same age. Similar results were found by various other researchers. (Ellinghaus & Schlag, 2001; Reiß & Krüger, 1995)

In contrast to the previous results depending on the driving situation the influence of a passenger on the driving situation can be negative. Reiß and Krüger conclude that in traffic situations with low speed a passenger increases the accident risk because a further reduction of the driving speed is not possible, which is a consequence of having a passenger. An increase in the accident risk due to a passenger can also be valid for unexperienced drivers (Reiß and Krüger). More studies, conducted in Maciej, confirm that a passenger can have a negative influence on the driver. The conclusion of the studies is that the passenger is a distraction for the driver. The interaction with the passenger, for example having a conversation, is a reason to mention. To conclude, the question whether the influence of the passenger on the driving behavior is positive or negative is highly dependent from various factors as for example the current driving situation. In (Maciej, 2012), results referring to the difference between a conversation with a passenger or a call are summarized. Even tough talking does not interfere with the driving task it uses cognitive resources (Maciej, 2012; Reiß & Krüger, 1995). While the passenger can observe the driving situation and adapt the speed of the conversation, it is not possible for the conversation partner at the phone to adapt the conversation to the driving situation during a phone call. The term "Conversation Modulation" describes the difference between talking to a passenger and a phone call (Maciej, 2012). The passenger has the ability to observe the driver's behavior and his state. Furthermore, he can give comments and hence, influence the driver's actions and assist him. However, Ellinghaus & Schlag, 2001 found that passengers rather tend to not comment on the driving behavior even in dangerous situations. . Especially, passengers without driving experience do so. Even in the case of drowsiness the passenger does not react on the state of drowsiness of the driver. A reason not to warn is that the passenger does not feel the need to warn the driver about his sleepy condition as the driver is supposed to know what he does. Furthermore, commenting on the driving behavior and giving advice may insult the driver and implies that the passenger questions the driver's driving ability. A conflict between passenger and driver is not desired, therefore the passenger does not comment on the driving behavior. (Ellinghaus & Schlag, 2001)

In the case of drowsiness, especially for the concept of the driver assistance system, the influence of having a conversation even via a phone call is the preferable measure against drowsiness compared to listening to radio, pushing a button frequently and vibration (Greschner, 2011). Compared to a real passenger the effect could be even higher due to conversation modulation. In our concept of a driving assistance system against drowsiness, a virtual passenger is implemented which can interact with the driver. By talking and entertaining him without demanding too much cognitive resources, it can prevent drowsiness. Furthermore, the driving assistant system can, as well as a real passenger, interrupt its action depending on the driving situation. Certainly, the goal for future driving assistance systems can be to act as a real passenger with an optimized behavior.

2.2 Gamification

In recent years, the term gamification gained popularity in academics as well as in various fields of industry. While gamification is defined as "use of game design elements in a non-game context" (Deterding, 2011), it is widely used to encourage a desired behavior. In the following, a review on gamification related to the project work is given. The game design process in general will be explained in order to understand the basic concept of developing a gamified system. Finally, existing gamified driving assistant systems are presented.

2.2.1 Review on gamification

In the driving context gamification is used to make driving less boring, since driving can be repetitive or monotonously, especially on long distance rides on the highway. The concept of gamification has already been applied successfully in different sectors, such as finance, health and education. By using game elements, a higher motivation is induced (Schroeter, Oxtoby, & Johnson, 2014). In the automotive sector, gamification concepts are already available for the purpose of marketing but also for efficient and eco driving. Volkswagen for example used a gamified marketing concept to promote their new *Bluemotion* car. The goal of the game was to guess how far the new car can drive with a full fuel tank. Therefore, they had to analyze the car's features. A real car drove down a route in Norway which was visible online on *Google Maps*. An important feature of the game was that, via *Facebook*, the participants could bet on single roads nobody had bet on before. Hence, different participants could challenge themselves in real time on *Facebook*. More than the extrinsic reward of winning a new *Bluemotion* car, for many participants the intrinsic motivation was to beat other participants and challenge them (Diewald, Möller, Roalter, Stockinger, & Kranz, 2013). Further examples for gamification in other fields in the automotive sector, especially for eco-driving, can be found in literature (Schroeter et al., 2014) (Diewald et al., 2013).

By gamification the driver is motivated to drive more safely. However, the game design approach has to take into account that a lasting safe driving behavior is desired. Therefore, challenges have to be supported by a reward system to create a motivating behavior.

Diewald et al. pointed out that in order to create motivation the game has to meet several requirements like being satisfying that there is hope of being successful, that it has a meaning, as well as the possibility to connect it with social networks. For the game being satisfying, the game has to have a goal, rules and a feedback system. Regarding the rewarding in the game design.

Schroeter et al. classified rewards in 4 categories as in the following. Firstly, rewards of glory can consist of a table comparing the driver to previous driving results or trophies for achieving goals. Moreover, rewards of sustenance consist of maintaining the driver's status by enabling the driver access to special features. Lastly, rewards of access and rewards of facility provides the driver with new features in terms of location and abilities (Schroeter et al., 2014).
The benefits of a gamification for the driving behavior have been found in the study of Verwey & Zaidel,. They investigated the effect of a *gamebox* on the driving behavior in monotone situations. Therefore, they implemented a *gamebox* as a secondary task. The *gamebox* offered twelve different games of three different categories based on measuring the time, distance and speed and additional auditory games, as well as games based on recording the driver's voice. The interaction between the driver and the *gamebox* is vocal and auditory, resulting in a self-paced activity. The individuality of the game makes it comfortable by using the *gamebox* and taking into account the traffic situation and the mental activity. The study investigated the driving performance, drowsiness, mental effort and the extent of using the *gamebox* by measuring the mimic of the driver and analyzing the vehicles data for the vehicles position or gearing angle. It is to mention that the participants in the study already practiced with the *gamebox* in advance of the study. The results show that the *gamebox* is an effective countermeasure against drowsiness and helps the driver to improve his driving behavior in monotonous situations. Compared to the control condition, the driver who used the *gamebox*, had fewer accidents and incidents. In fact, the control condition had approximately twice as many incidents. The positive effect is higher for less experienced drivers than for more experienced drivers. Furthermore, the drivers reported that the *gamebox* is useful to them and it helps them handling the driving tasks. The authors concluded that a mentally loading activity helps to drive safely and attain awareness in monotonous, long driving situations. However, the mentally loading activity, as the games provided by the *gamebox*, has to remain interesting and demanding at the same time. New games could possibly provide even greater effects. (Verwey & Zaidel, 1999)
For the design of a gamified in vehicle system the study of Vaezipour et al. provides insights of the user experience with different conceptual gamified designs. In these study 34 participants were discussing eco-safe driving and their concerns about that topic. Afterwards, the participants were shown gamified eco-safe in vehicle systems which they should discuss again with the background knowledge of the previous discussion. The findings of Vaezipour et al. are summarized in three major sections, namely the user perception of the gamified system, incentive and motivation to use the system and social persuasion feedback. The results highlight the users' perception of the gamified concept, especially in the context of safe driving. For the users' perception, the users gave different feedback regarding the benefit of a gamified system. However, the majority of the participants stated that the gamification of the system should be more of a background feature while it is more important to be given information and feedback directly. Moreover, the long-term effect of gamified elements was questioned. Instead, a personalized system with positive feedback was favored. The intrinsic motivation related to the gamification of the system would not be the motivation for the participants to use the gamified system. In fact, knowing that the system could benefit the driving behavior and save fuel would be enough for some of the participants to use the system. The participants who favored extrinsic rewards suggested that the extrinsic rewards should be related to the driving task as e.g. receiving fuel vouchers. The participants stated that having your social environment participating increases the use of the gamified system among the users. Finally, the authors conclude that the game elements should be an optional background feature. The participants clearly highlighted that autonomy and control of the system are important criteria since a personal and individual system is favored (Vaezipour et al., 2016).

2.2.2 Game design process

In the following basic game design elements, which are defined by the video game sector, are presented. The understanding of the development of video games helps to create a proper game design in the automotive sector. Based on the game design approach, the game design can be divided into 5 layers which are also shown in Figure 2.2:

- Verb: Bottom layer which represents the simplest action the driver can use. The verbs are usually activated by the drivers input on an HCI. In a vehicle, the HCI will define in dependency on the situation the availability of the possible verbs.

- Mechanics: The mechanics are, as the name implicates, the construction and the algorithm of the system. The desired action (verb) will be realized by the mechanics by evaluating the input made by the driver. In a traffic situation, the mechanics will have to analyze the situation at any time and the output must not put the driver in danger.

- Core: The core represents the type of information content the driver interacts with, as well as its characteristics. It defines the type of game the driver will experience with its challenges. In the core design content and properties of the game are described. Furthermore, the challenge has to be adaptable, thus the driver can adapt the difficulty level to his demands.

- Theme: The theme will extend the core by introducing a character and a look. It accounts for the first impression of the driver and the driver's perception/acceptance of the game.

- Concept: By putting all layers together the concept can be evolved. It is the overall description of the game with its look, contents and properties by summarizing these. It can be the starting point for an iterative process or a top down approach.

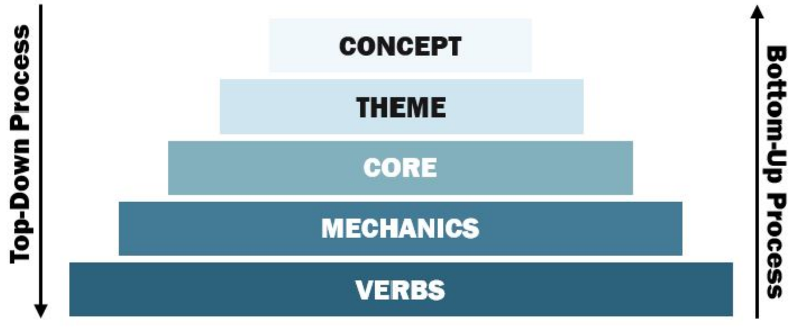


Figure 2.2: Different layers of the presented game design approach

Based on the game design approach either a top down or bottom up approach is applicable. However, for safety purpose a bottom up approach is recommended. Furthermore, focusing on the whole concept rather than considering all layers of the presented approach may help to improve the design and benefit the concept by taking into account all possible features and interaction elements. (Steinberger et al., 2015)

2.2.3 Existing gamified assistance systems (against drowsiness)

For the purpose of safe driving, two realized existing gamification applications can be found in literature. In *CleverMiles* the user obtains *CleverPoints* for safe driving which the driver can cash in for different products provided by partners. The *CleverMiles* application is realized by an external device which is connected via the ONB and can analyze the driving behavior. Furthermore, it features a display for recommendation and a possibility to share your results on *Facebook* (Diewald et al., 2013). In the other application, named Driving Miss Daisy, a virtual passenger is evaluating the driving behavior. The driver drives *Miss Daisy*, who is shown in Figure 2.3 to the driver's destination while she accompanies him by commenting on his driving behavior. At the end of a ride Miss Daisy gives a brief summary of the driver's performance. The app uses audible feedback to ensure that the driver does not have to focus on the display. It rewards smooth riding with constant speed, acceleration, deceleration and driving within the driving limit. The reward system is divided into three rewarding types. The signs *thumbs up* and *down* are shown instantly as basic feedback. A game score is the weighted sum of all points obtained during driving. Finally, the driver virtually obtains money for each round the driver plays to tie the driver to the game for longterm purposes. Also, the difficulty is adaptable. The app is a HTML5 application and collects data from the OBD. With the software *MirrorLink* a connection from the smartphone with the dashboard is established. (Diewald et al., 2013; Shi, Lee, Kurczal, & Lee, 2012)

Figure 2.3: Virtual Co-Driver in the Driving Miss Daisy app (Shi et al., 2012)

2.3 Human centered design process

This project is based on the human centered design process. The human centered design process improves the design process and development of products, systems and services. For our work especially, a human centered design process is essential as it ensures a safe and useful system for the user. The basic concept for the human centered design process is a four-staged iteration process shown in Figure 2.4. Based on a previous ADP which resulted in a click dummy assistance system, the context of use is defined to ensure that the design process considers all activities needed, the working environment and the understanding of the user. Therefore, the context of use was divided into the context of use for the driver in the driving simulator and the context of use for t*he wizard of Oz*-experimenter who controls the assistance systems activity. After defining the context of use, a list of requirements is determined which is used to elaborate different solutions. The last stage of the iteration process is the evaluation of the design solution. (Deutsches Institut für Normung e.V., 2010)
A main characteristic of the human centered design process is that it is an iterative design process. After evaluating the iteration process can be restarted from a previous iteration stage if needed. Figure 2.4 illustrates the human centered design process.

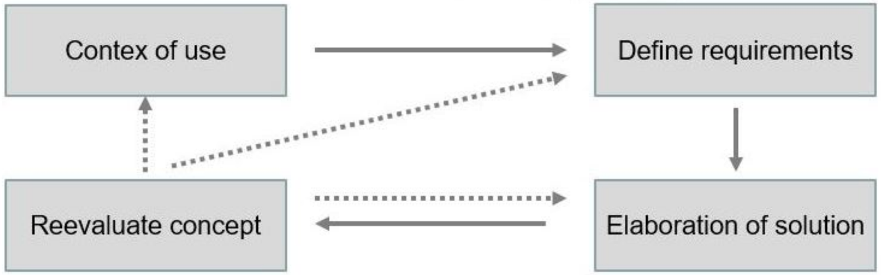


Figure 2.4: Human centered design process with the previous ADP as a starting point

2.4 Wizard of Oz Experiment

Wizard of Oz Experiments are used to simulate the interaction between a person and a computer interface. In this type of experiment there is a test person who interacts with a system that can not work autonomously. Spaced apart from the test person another person, the “wizard”, controls the whole system. That means, that the interacting person only assumes to be directly connected to the system. In fact, the whole communication between the person and the computer interface is controlled by the “wizard”. So, the test person behaves like in a real experiment, even if the whole interaction is based on the activity of the “wizard”. (Dahlbäck, Jönsson, & Ahrenberg, 1993; Hajdinjak & Mihelič)
In the case of this thesis a software prototype is developed, to simulate the interaction between a driver in a driving simulator and a driver assistant interface.

2.5 Used software in this project

2.5.1 Axure

The software used to build up the prototype is called *Axure*. *Axure* can be used for rapid prototype of websites and apps without programming skills. The *Axure* environment provides the user numerous tools and graphics to design interactive wireframes. Therefore, *Axure* is suitable not only for concept and design purposes but also for rapid prototyping. A drop-down list provides graphic tools while a dynamic panel is used for interactivity. *Axure* is rich of interaction possibilities. The dynamic panel can have different states and follows a certain logic in relation to an event depending on the desired interaction. The finished wireframes are created as HTML websites and can be shared easily. Figure 2.5 shows the interface of *Axure*. In the middle of the interface the design page can be found which is called canvas. On the top the main menu and main toolbar provides central functions like for example saving files. From top to bottom on the left side the pages are listed, a library provides the user with predefined widgets, shapes and images and lastly masters can be organized. The part on the top right side which is called inspector lets the user control the interaction between the shapes, widgets etc. Finally, on the bottom right side a list including all features used within the project is provided for filtering, searching and sorting purpose (Axure: Interaktives Wireframe Tool für Webseiten und Apps, Intro to Axure RP).

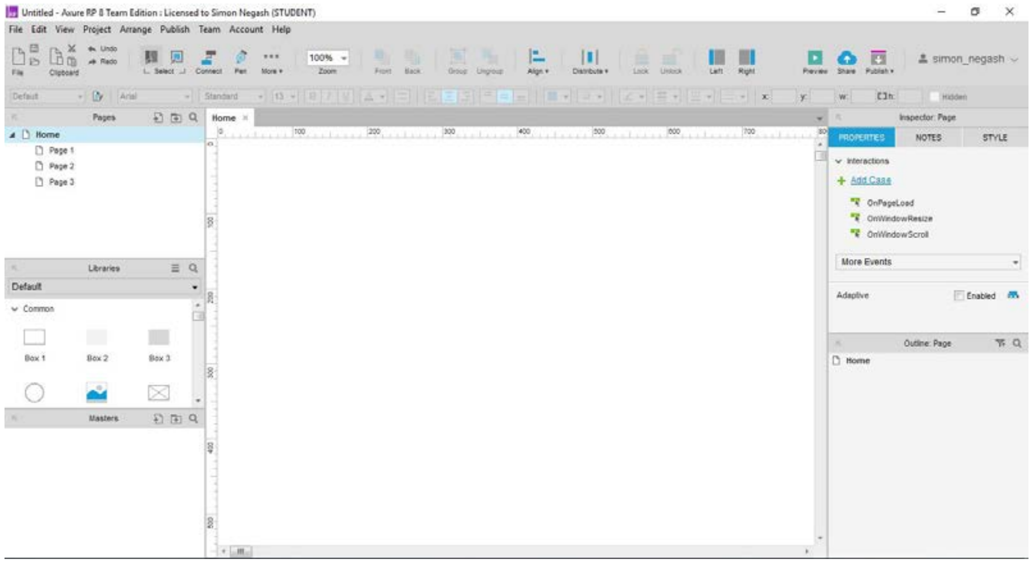


Figure 2.5: Interface of *Axure*

2.5.2 From text to speech converter

This work uses the website http://www.fromtexttospeech.com/ to convert written texts into an audio files. The settings for the conversion are listed in Table 2.1:

Table 2.1: Settings for audio conversion

		Language	
		English	German
Setting	“Select language”	British English	German
	“select voice”	Emma	Nadine
	“select speed”	medium	Medium

2.5.3 Hostinger and FileZilla

Axure enables to open websites within a page with the help of a feature called *inline frame*. It is explained in chapter 5.6 in detail. This feature can open links to websites and show its content in a small section of the screen. It is also possible to open websites which audio files are hosted on. This allows to integrate these audio files into the *Axure* prototype. That's the reason why it is necessary to host audio files on a website. Within the scope of this ADP an account at the Hosting-Service website *Hostinger* is created. This account allows to host all kind of files online. The URL for the website, where all audio files for this work are hosted, is http://www.wozprototype.esy.es/. Furthermore, an account at the E-mail provider *Googlemail* was generated to manage the *Hostinger*-account. All data to handle both accounts can be found in appendix A. Additionally, an overview over the register of the hosted files is given.

To manage and administrate the upload of data, the software *FileZilla* is necessary. It allows the data transfer from a local to an online location.

2.5.4 TeamViewer and Screenleap

TeamViewer is a software which allows to pair and mirror two computer screens. The connection is established via internet and works with the internet protocol. Therefore, the program generates a partner ID and password. The ID can be used by the user of the partner screen to connect both screens. The software makes it possible to share the screen from the local client with the remote client. (TeamViewer Features; Wikipedia, 2017). *Screenleap* is similar to *TeamViewer*. It allows to share two connected computer screens. Unlike *TeamViewer*, *Screenleap* only needs a program installation for the server desktop, the paired screen is connected via the web browser (Free Screen Sharing | Screenleap).

3 Concept

3.1 General Background

As already explained in chapter two, a co-driver has a positive influence on a driver, who has to drive under monotonous conditions. A co-diver helps to prevent the driver of drowsiness and dangerous situations, which might occur as a result of the monotonous environment. Next to the role of the co-driver, another concept to influence the behavior of a driver in a positive way is presented in chapter 2. A gamified driving task can influence the behavior of the driver. The previous ADP of Amini et al. picks up these ideas and combines it to a concept of a virtual co-driver, who gamifies the driving task. This concept makes the driving task less monotonous and has additionally the potential to improve the behavior of the driver. So far, the concept is only realized as a click dummy.
To investigate this concept, it is strictly necessary to perform test rows to collect data about the influence of such a system on the physical state of the driver in the driving simulator of IAD. So far it is not possible to implement an assistant system into the driving simulator software. Hence, the test rows have to be performed as *Wizard of Oz* -experiments. This work picks up the concept of the previous projects and creates a software prototype by using the software *Axure*, which is introduced in chapter 2.5. With the developed software prototype, it is possible to perform *Wizard of Oz*-experiments in the driving simulator of IAD. These experiments allow an investigation of the influence of a gamified virtual co-driver on the behaviour and the physical state of the driver.

3.2 Games and Quiz

The main features of the concept are gamified tasks for the driver, which are added to the driving task. In the presented work, these tasks are three driving games and a quiz. The virtual co-driver suggests the driver to play a game or a quiz to break the monotony of the driving task. The communication between driver and assistant system is designed as a conversation between real people. The games and the quiz are to be designed in such a way, that they do not put cognitive load on the driver to an extent where the driving activity is affected.
The concepts of the three games are developed by Amini et al. and listed below

- Maintain the position in the middle of the driving lane for 60 seconds
- Maintain the speed for 60 seconds
- Maintain the distance to the vehicle ahead for 60 seconds

The logic behind the choice of games are explained in detail with analyses in Amini et al., and is summarized as below:
During a long drive on a highway under monotonous conditions, drivers usually engage themselves in several unique behaviours to counter the drowsiness induced by this monotony. Some of these are frolic activities to gamify their driving task. The best or most common of those are represented by the chosen games for this project. Some of the most common driving errors caused by monotony are also countered directly by these games. Drifting away from the lane one's vehicle is on, erratic speed and acceleration, getting too close or too away from the vehicle ahead are those errors. (Amini et al., 2016)
It is strictly necessary for the aspect of gamification, that the driver gets a feedback about his game-performance. The developed prototype gives the opportunity to rate the game performance of the driver basing on the collected data about the driving behaviour. This is explained in detail in chapter **Error! Reference source not found.**.

4 Context of use and requirements

In this chapter, the context of use for the prototype is pointed out. After defining the context of use, requirements for the surface of the prototype are derived. This thesis focuses on the development of the software prototype to perform *Wizard of Oz*-experiments in the driving simulator of IAD. For an extended description of the concept design of such an assistant system in a real driving scenario, this thesis refers to the work of Amini et al.

4.1Context of use

The *Wizard of Oz*- experiments, which will be performed after this thesis is finished, take place in the driving simulator of IAD at TU Darmstadt. The simulator is shown in **Error! Reference source not found.**:

Figure 4.1: Driving simulator IAD (IAD TU Darmstadt)

Two people are involved into these experiments: A driver, who sits in the simulator car, and a “wizard”-experimenter, who monitors the driver in the background. Hence, it must be distinguished the context of use for these two involved persons in the following two subchapters.

4.1.1 Context of Use for the Test Driver

The test driver sits in the simulator car, which is equipped with the assistant system, which is developed in this work. Figure 4.2: Cockpit (Amini et al., 2016)shows the cockpit schematically.

Figure 4.2: Cockpit (Amini et al., 2016)

The in- and output channels, which are used for the communication with the assistant system are highlighted. To give input, the driver can use his voice. The audio output of the assistant system is presented by speakers, the visual output can be presented by the LCD or the HUD.

4.1.2 Context of Use for the *Wizard of Oz* -Experimenter

The Simulator runs with a software called *Silab*. Next to the projection of the track, it can also collect data on the current driving behaviour (IAD TU Darmstadt). The experimenter sits at a desk behind the simulator screen and controls the interaction between driver and assistant system with the

Axure software to analyse the driving behaviour *Silab* gives output on several screens, which are located on a desk behind the simulator screen. The experimenter is the interface between the simulator software *Silab* and the *Axure* prototype. The fundamental functionality is shown in Figure 4.3:

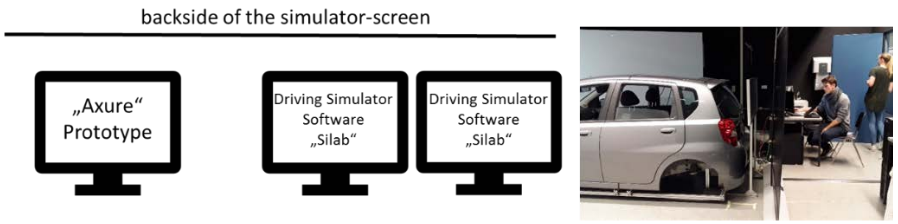


Figure 4.3: Context of use for the wizard

4.2 Requirements

This work focusses on the development of a human-computer interface. To define requirements this work is oriented towards ISO 9241-110, which contains the seven principles for dialogue design.
The principles and the requirements, which are derived from them in the context of this work, are listed in the following chapters. (Deutsches Institut für Normung e.V., 2006)

Suitability for the task
The central task, which this prototype is used for, is the controlling over the communication between assistant system and test driver. The striven *WOZ*-experiments must be operable. The communication between system and the assistant system must be as less delayed as possible. To guarantee this, the wizard experimenter needs a graphical interface, which can nearly fully be operated by mouse clicks and with as few input by keyboard as possible.

To understand the behaviour of the driver, the interface, which is seen by the driver, must be visible for the experimenter as well.
As already in the work of Amini et al. mentioned, many influences must be considered to create questions for the quiz, which appropriating in a context of the driving task. In addition, the whole interaction between assistant system and driver must be handled by speakers and voice of the driver. It can be compared to a short dialog, containing just question, answer and feedback. In this way, the task to answer the question and a corresponding distract from the driving task is minimal.
The questions and the corresponding answers must be clear. Furthermore, the difficulty must be high enough to guarantee that the monotony is broken but low enough to not distract from the driving task. In addition to reduce the potential of stress for the driver there must be no time limit to answer and a repetition of the question must be possible.
Self-descriptiveness
The interface of the prototype must be usable after a short introduction by a developer of the prototype or after reading this work.

Conformity with user expectations
For the *WOZ*- experiments the test person and the experimenter are not allowed to communicate physically or orally. In this context, every in- and output of the driver must be doable by voice. The experimenter has to handle any situation without asking the driver by voice. He needs to stay completely invisible and inaudible.
Suitability for learning
Short explanation texts appear when the mouse courser moves to an icon or a button. They provide information about when to click on them and what action is triggered by clicking.

Controllability
The behaviour of the driver causes a reaction by the assistant system, which is controlled by the experimenter. It is essential for the prototype, that the

experimenter can react on unexpected scenarios while driving, for example deer crossing or emergency brake. In this case, all experimenters must be able to interrupt all running features, so that the driver can pay his full attention on the driving task. Next to emergency scenarios, the driver must be able to close or pause the assistant system only by voice.

Error tolerance

A typical error scenario for the work with this prototype would be an unintentional activation of a feature by the experimenter. In this case, there needs to be an opportunity to stop the wrong running feature and replace it by starting the proper one. According to the suitability for the task, an input by the keyboard has to be minimized. Thus, for the prototype, auto-correction for input by the keyboard has to be eliminated.

Suitability for individualization

The development of the prototype takes place in a German-Indian context. As a result, the interface of the prototype must be settable in German and English language.

5 Development of the prototype

The way the *Axure* prototype is integrated into the driving simulator is explained in this chapter. Afterwards, the implementation of the concept in *Axure* is documented. All features are descripted and explained in the following chapters. In the end of the chapter, the used *Axure*-features to implement essential features of the prototype are shown.

5.1 Integration into the driving simulator

As already explained in chapter 4, a HUD, a LCD and audio speakers are used for the communication between assistant system and driver. Figure 5.1 illustrates how the various components of the driver interaction system are integrated into the *Silab* based driving simulator:

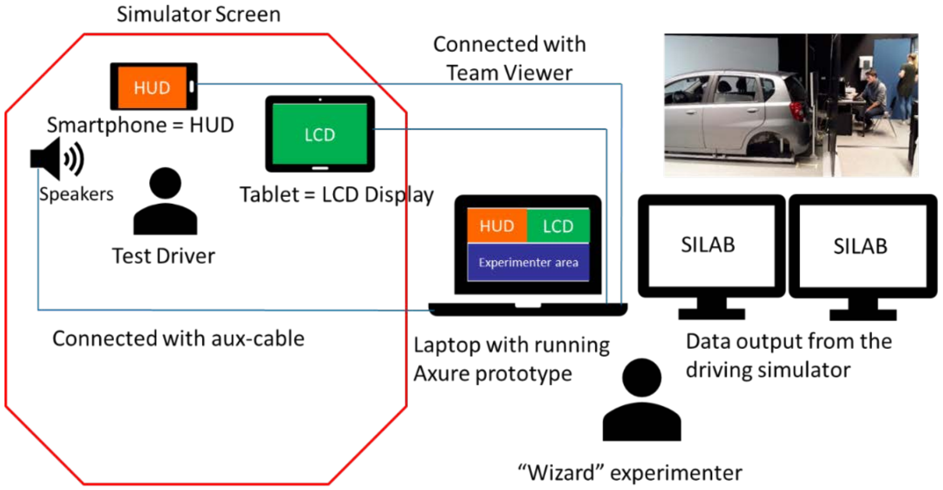


Figure 5.1: Concept to implement the prototype into the driving simulator

Although the *Axure* interaction system is prototyped outside the SILAB system, it is built in a way that it could function independently. At the same time, it is supposed to integrate into the environment through the inputs from the user of the *Axure* interface.

To deploy the driver interaction system, which is built with *Axure*, the following installations are to be made in the simulator.

Table 5.1: Features and their implementation

Feature	Realisation	Connection
HUD	A smartphone (*Samsung Galaxy S4*), which is placed on the board right in front of the windscreen. It shows the mirror inverted content of the HUD and projects it onto the windscreen of the simulator car.	Shared screen with *TeamViewer*
LCD	A tablet (*Huawei MateBook*), which is placed on the dashboard, shows the content of the LCD.	Shared screen with *ScreenLeap*
Audio output	Additional speakers bough off-the-shelf	Aux-cable
Voice input	Voice of the driver	Ears of the “wizard”-experimenter hear the voice of the driver

TeamViewer is used as an application on the *Android*-smartphone. It is important, that the screen of the Smartphone is switched on for a long time and does not turn off automatically. Therefore, the application *KeepScreen* is installed additionally. It keeps the screen of the smartphone switched on with full brightness for selected applications. With this application, it is possible to keep the screen switched on as long as *TeamViewer* is active.
Unfortunately, *TeamViewer* showed compatibility problems, when it is used on the *Windows*-tablet in the context of this project. That’s why the software *Screenleap* is used to show the wireframe of the prototype on the *Windows*-tablet.
The implementation of the features is shown in Figure 5.2: Implementation into the driving simulatorFigure 5.2. The cockpit of the simulator car with the LCD on the middle console and the projected HUD on the windscreen is shown on the left picture. On the right, the corresponding interface for the experimenter is shown. The audio speakers are in foot-area of the co-driver’s seat.

Figure 5.2: Implementation into the driving simulator

5.2 General Interface

The prototype consists of ten pages in total. In detail, it consists of one page for the start procedure, three pages for the driving games and one page for the quiz. Each page exists in English and German language.

The general surface of the prototype is separated in three areas. It is shown in Figure 5.3:

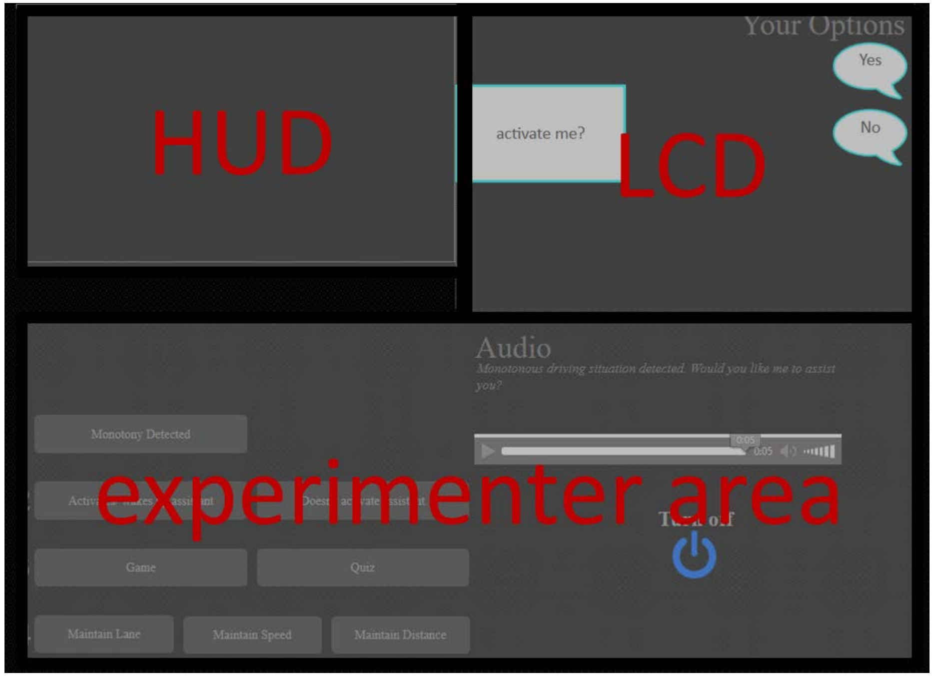


Figure 5.3: General interface areas

The content of HUD and the LCD, which are shown to the driver as explained in chapter 4, are visible for the user in the upper area. The content of the HUD is shown on the left. Its size is fix and accords with the proportions of the smartphone which projects the HUD onto the windscreen. On the right side the LCD is shown and it is also adapted to the proportions of the tablet, which represents the LCD in the experiments. The proportions of the smartphone are 16:9 and the proportions of the tablet are 3:2.

In the bottom screen area, the interface for the experimenter is placed. This area is visible for the experimenter only. By this interface, it is possible to show the experimenter the content of the HUD and LCD. This ensures the controllability, which was mentioned in the requirements for the experimenter.

In general, the driver can give input by his voice. If the driver interacts with the system, the wizard must trigger the corresponding action, by clicking a button in the experimenter area. As illustrated in Figure 5.3: General interface areasthe possibilities, what the driver can input to the assistant system are shown on the LCD with speech bubbles. This kind of interaction to use the assistant system must be explained well to the driver before an experiment in the driving simulator starts.

5.3 Start and shut down

To start the prototype the experimenter opens the preview of the start page with *Axure*. In the internet-browser, which performs the preview, the full-screen-mode must be activated. Afterwards the screen needs to be shared to the smartphone and the tablet in the cockpit as explained in chapter 5.1. The HUD and the LCD must be adjusted by zooming to the corresponding screen area.

The experimenter chooses the language by opening the preview in German or English language. All other pages, which get loaded from the start page, are to find in the corresponding language setup. The page “Start English” is shown in Figure 5.4:

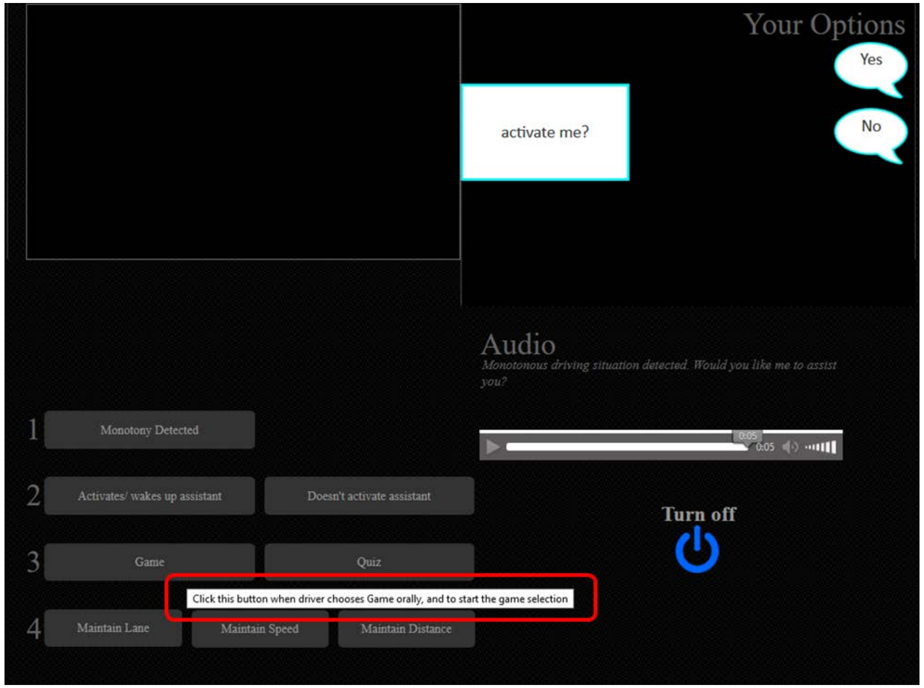


Figure 5.4: Start page

The first interaction between driver and assistant system is designed as a short dialogue. After the activation of the first button "Monotony Detected" by the experimenter, the driver gets the information, that a monotonous driving situation was detected and he is asked, if he wants to start the assistant system. In case of the driver agrees, he must decide between a driving game and a quiz. If he chooses "Quiz" the start dialogue is completed and the page "quiz English" or "quiz German" gets loaded, depending on the language setup. Before starting a game, the driver is asked which game he would like to play. After this step, the page "hold lane", "hold speed" or "hold distance" is loaded. In case of a German language setup, the loaded pages are "Spur halten", "Geschwindigkeit halten" or "Abstand halten".

As explained in the previous chapter, the driver interacts with the system by voice. The different states of the start- dialogue, which are shown on the LCD are listed in Table 5.2: States of the start-dialogue

Table 5.2: States of the start-dialogue

State	Decision	Responses
Monotonous driving situation detected	"Activate me?"	"Yes" and "No"
Driver agrees to activate assistant system	"Game or Quiz"	"Game" and "Quiz"
Driver disagrees to activate the assistant system/ assistant snoozing	-	"Wake up" and "Turn off"
Game selection	"Which game?"	"Holding Lane", Holding Speed" and "Holding distance"

The text of the left speech bubble substantively corresponds with the current hearable audio output. The feature *to snooze* the assistant system gives the driver the opportunity to refuse an activation at that time and to start later. The HUD is not active during the start procedure to avoid that the driver gets distracted by the driving task.

5.4 Driving games

Each game is integrated into the *Axure* prototype with an own page in each language. In this chapter, the game interface is explained in general. Further, the rules and the scoring system for the games are illustrated. Afterwards, the game specific scenarios and their implications for the actions of experimenter and assistant system are shown.

5.4.1 Game Interface

The game interface is made up of specific areas, which are shown in Figure 5.5 and explained in Table 5.3:

Figure 5.5: Game interface areas

Each area is described in Table 5.3: Explanation game interface areasTable 5.3. Most of them are explained in detail in the following chapters, what is noted in the table.

Table 5.3: Explanation game interface areas

Area in figure	Explanation
Game-specific icon on the HUD	gives a feedback on the HUD to the driver during the game; (chapter 5.4.3.)
Feedback area	area where the visual feedback appears when a game is finished
Possible input	Shows the driver his or her next possible voice input
Time-line	illustrates the driver the duration of the game with an extending rectangle from the left side to the right side of the HUD
Game specific input	input-field for the experimenter to edit the game conditions (chapter 5.4.3)
Time counter	countdown for the experimenter to show the remaining time of the game
Buttons to start	button to start the game in blue and another button in grey to repeat the audio introduction of the game for the driver
Current score	shows the score of the current performance of the driver (chapter 5.4.2)
Current/ last audio	shows the current/ the last audio output, which is/was given to the driver.
Buttons for gaming behaviour	buttons to rate the game performance of the driver and to create the score (chapter 5.4.3)
Buttons for non-gaming behaviour	buttons to manage scenarios, which pause, resume and restart the game (chapter 5.4.4)
Icon to shut down	shuts down the assistant system and leads to the start page

5.4.2 Rules and scoring

As already explained in chapter 3, a rating system for the driving games must be integrated into the prototype. The “wizard”-experimenter serves as interface between the simulator software *Silab* and the *Axure* prototype. The simulator supplies data on the current state of the car. For the three games an output of the lateral position, speed and the distance to the vehicle in front is necessary. Based on this output, the experimenter can rate the current behaviour of the driver by clicking buttons on the *Axure* interface. Thus, the experimenter has two main cognitive tasks: On the one hand the identifying of the data and on the other hand the clicking of the right button. In doing so, the actuality of the feedback depends on the frequency of the rating performance of the experimenter. Here a conflict of objectives is noticeable, because the experimenter needs a certain amount of time to handle the two tasks. In this work a compromise is defined. The experimenter is given a time period of three seconds per rating, which results in twenty ratings per game.

To rate the performance of the driver, specific indicators for each game must be defined. The rating of the challenge to hold the lane is the deviation from the ideal position in the exact middle of the lane. For the “holding speed”-game, it is the deviation from the beginning speed. A deviation of less than 2% from this beginning speed is rated good, a deviation between 2% and 5% neutral and a deviation over 5% bad. The game to hold the distance to the car ahead orientates on the distance in the beginning of the game. A reduced distance is immediately sanctioned with a bad rating, a constant and an extended distance up to 110% of the distance at the start are rated good and

a distance more than 110% of the start distance is rated neutral. These rules are based on the conception of Amini et al. and have been adapted. According to the investigations of Green, Cullinane, Zylstra, & Smith, a standard deviation of the lane position of 26 centimetres is identified. This thesis agrees with the assumption of Amini et al., that the driver is extraordinarily concentrated on the lane position during the game. Hence, a deviation of less than 15 centimetres is rated good, a deviation between 15 and 25 centimetres is rated neutral and a deviation of more than 25 centimetres is rated bad.
The ranges of all three games are estimated. Real experiments in the driving simulator need to be performed to verify these values. Scoring rules are summarized in table

Table 5.4: Rating rules

Game	Indicator	Good rating	Neutral rating	Bad rating
Holding lane	variation from middle position of the lane	deviation of less than 15cm	deviation of more than 15 and less than 25cm	deviation of more than 25cm
Holding speed	speed in the beginning of the game	deviation of less than 2%	deviation of more than 2% and less than 5%	deviation of more than 5%
Holding distance	distance in the beginning of the game	extension of less than 10%	extension of more than 10%	reduction

Each rating of driving behaviour corresponds to a score. A good rating implements a score of three, a neutral rating a score of two and a bad rating a score of one. Each score is added up to build the total score. As explained in this chapter, the experimenter gives twenty rates per game, resulting in a maximum score of sixty. Even if the driver performs badly, he is rewarded with a minimum score of twenty. By this scoring system, the driver achieves a score, even if he does not cope the challenge well, in order to stay motivated.
The system is illustrated in a flow chart in Figure 5.6: Scoring flowchart

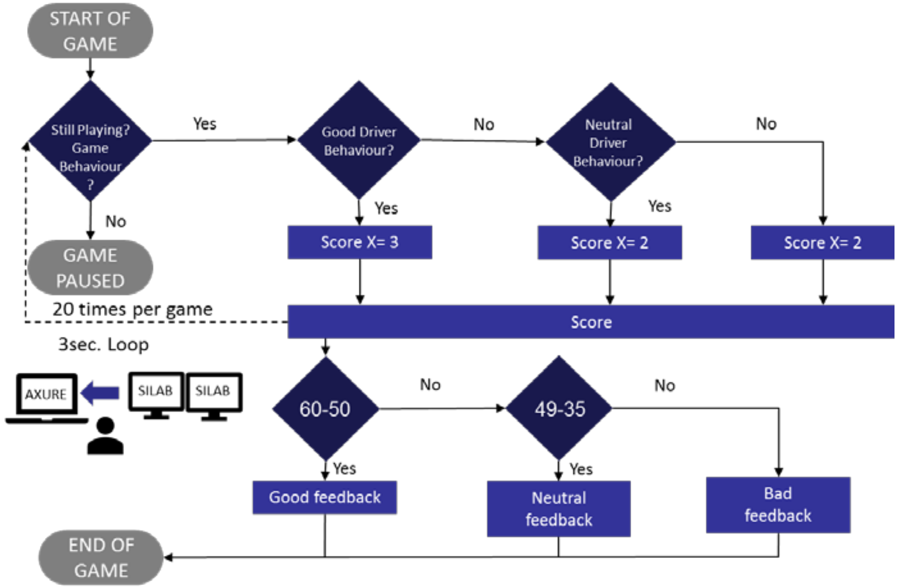


Figure 5.6: Scoring flowchart

Depending on the total score after the game, the driver receives a visual and an audio feedback. The audio feedback and the visual feedback are visualized by filled thumbs and listed in Table 5.5: Feedback after a game

Table 5.5: Feedback after a game

Feedback	audio	visual

Good	That's a good one. Would you like to play again? Otherwise you can also play another game or a quiz.	
Neutral	Not bad! Would you like to play again? Otherwise you can also play another game or a quiz.	
Bad	You can do better than that. Would you like to play again? Otherwise you can also play another game or a quiz.	

5.4.3 Game Specific Scenarios

After the page is loaded, an audio instruction about the following challenge of the driver is given. The instruction can be repeated as often the driver wants. If he is ready to start, the game begins by a click on the start button by the wizard. A three-second countdown is triggered and afterwards the game time is started. The introduction texts are listed in Table 5.6:

Table 5.6: Introduction texts

Game	Introduction text
Holding lane	Hey! Hold your lane steady for 60 seconds and drive along the middle of the lane.
Holding speed	Let's see, if you can hold the same speed continuously for 60 seconds.
Holding distance	Let's see if you can maintain the same distance with the vehicle in front of you for 60 seconds.

To rate the current game performance of the driver, the experimenter has game specific buttons on the left bottom area. As explained in the previous chapter, the driver can show good, neutral and bad behaviour during the games, which is represented by the buttons. They are shown in Figure 5.7: Rating buttons

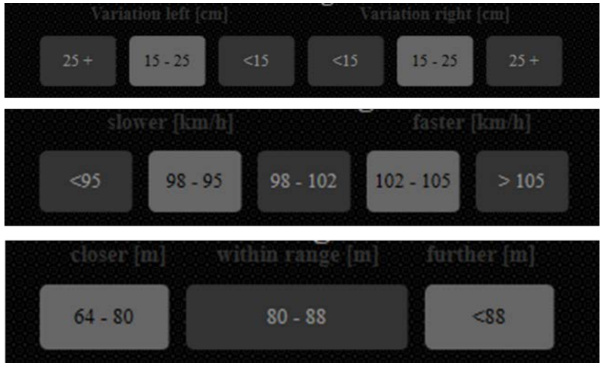
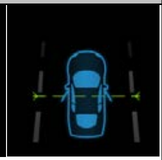
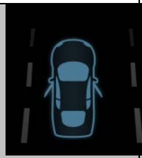
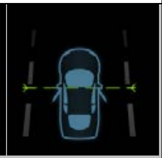
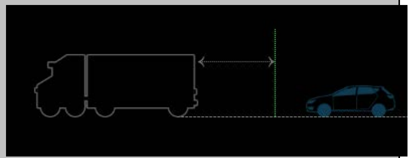
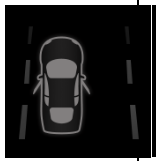
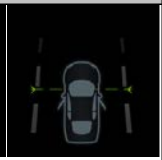
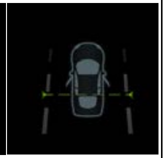
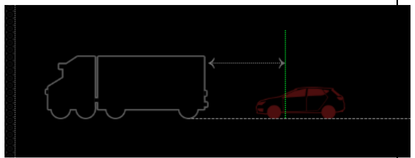


Figure 5.7: Rating buttons

The games for holding speed and holding distance need an extra feature, because the conditions to rate the current behaviour, depend on the conditions at the start of the game. With a digit input by the experimenter, the digits, which are shown on the buttons, change and give the correct ranges as listed in chapter 215.4.2.

Depending on the clicked rating button, the game specific icon of the HUD is modified to give the driver a feedback about his current performance. This feedback is an important feature to break the monotonous driving conditions. Without a changing view during the games, the monotony would return after playing the games often, because the visual environment does not change. The game specific feedback- icons are listed in the following table:

Table 5.7: Reactions of the HUD

Scenario	Reaction HUD		
	Holding lane	Holding speed	Holding distance
Good behaviour			
Neutral behaviour	 	 	
Bad behaviour	 	 	

5.4.4 Scenarios to Pause and Resume the Games

In a game situation many things can occur, which interrupt the game. These scenarios can be split up into two categories: dangerous situations, which require the full attention of the driver and safe situations, which pause the game but do not influence the safety of the driver. In the following table examples of scenarios, which pause each game a listed. It is not possible to give a general list for game-pausing scenarios, because each situation must be estimated individually.

Table 5.8: Scenarios

Game	Scenarios (examples)
General	Emergency break, Deer crossing
Holding lane	Lane change is necessary
Holding speed	Breaking because of traffic is necessary
Holding distance	Reeving vehicle in front, vehicle in front breaks or accelerates unexpectedly

To give the experimenter the opportunity to handle such scenarios, each game interface has buttons in the right bottom area. For the "holding lane"-game for example, a lane changing pauses the game. It is shown in Figure 5.8: Buttons for non-gaming scenario

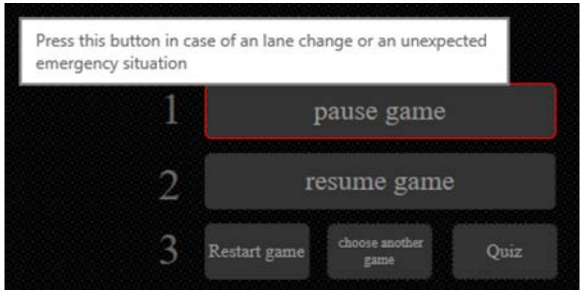


Figure 5.8: Buttons for non-gaming scenario

In a situation as mentioned, the experimenter must pause the game. The button-text in this area is the same for each game. The explanation, when the mouse cursoer stays on the button is different and adapted to the specific conditions.

Besides situations that influence the game in normal but safe scenarios, such as lane changing or a tailgating to a car ahead, a game can be interrupted by the experimenter, if a dangerous driving situation occurs. In case of an emergency break or unexpected dangers like deer crossing, the wizard must pause the application, since the driver's full attention is needed to handle the dangerous situation.

If a previously described situation occurs, the experimenter can react and pause the game with the button "game paused". After some time, the driver could come back into a situation, when the game can be restarted. In that case, the driver can communicate this to the driver with the button "resume game". Then an audio is triggered, depending on the game context. These sounds are listed in the following table

Table 5.9: Resuming texts

Game	Resuming text
Holding lane	OK. You are back in the lane. Would you like to play again? Otherwise you can also play another game or a quiz.
Holding speed	Ok. You are having a steady speed again. Would you like to play again? Otherwise you can also play another game or a quiz.
Holding distance to the car ahead	Ok. You once again a steady distance to vehicle ahead of you. Would you like to play again? Otherwise you can also play another game or a quiz.

Subsequently, it is up to the driver to restart the game or to choose another activity. If he or she agrees to restart the game, the driver is asked if he or she is ready, which is similar to a normal start. If he or she chose another activity, the quiz page or the start page to would be loaded. On the start page a new selection of a driving game is offered.
Furthermore, the assistant system can be snoozed and woken up by the driver with a corresponding voice input, which gives him the control about the activities he wants to do. The different states are listed in Table 5.10: Dialogue states for games**Error! Reference source not found.**

Table 5.10: Dialogue states for games

State	Decision	Responses
Before start	"Ready to start?"	"Yes, start" and "Introduction again"
Game is active	-	"Snooze" and "Turn off"
Assistant is snoozing	-	"Wake up" and "Turn off"
End of game/ assistant woken up	"What's next?"	"Play this again", "Another game" and "Quiz"

The actions, that are triggered when the driver "snoozes" the assistant, are similar to the button "pause game". The waking up actions are identical to the actions after "waking up" the assistant, except the audio text is changed to: *"Welcome back! Do you want to restart the last game or would you prefer to play another game or a quiz?"*

5.5 Quiz

When the driver chooses the quiz option after the starting dialogue, the page "Quiz" occurs. In case of this the HUD stays unchanged. When the page is loaded, the following introduction is played: "*Nice! You will be asked questions out of three random categories. If you want to hear the question again, say "repeat". To answer, speak your response out loudly. Have fun!"* The layout of the quiz page is shown in Figure 5.9: Layout quiz:

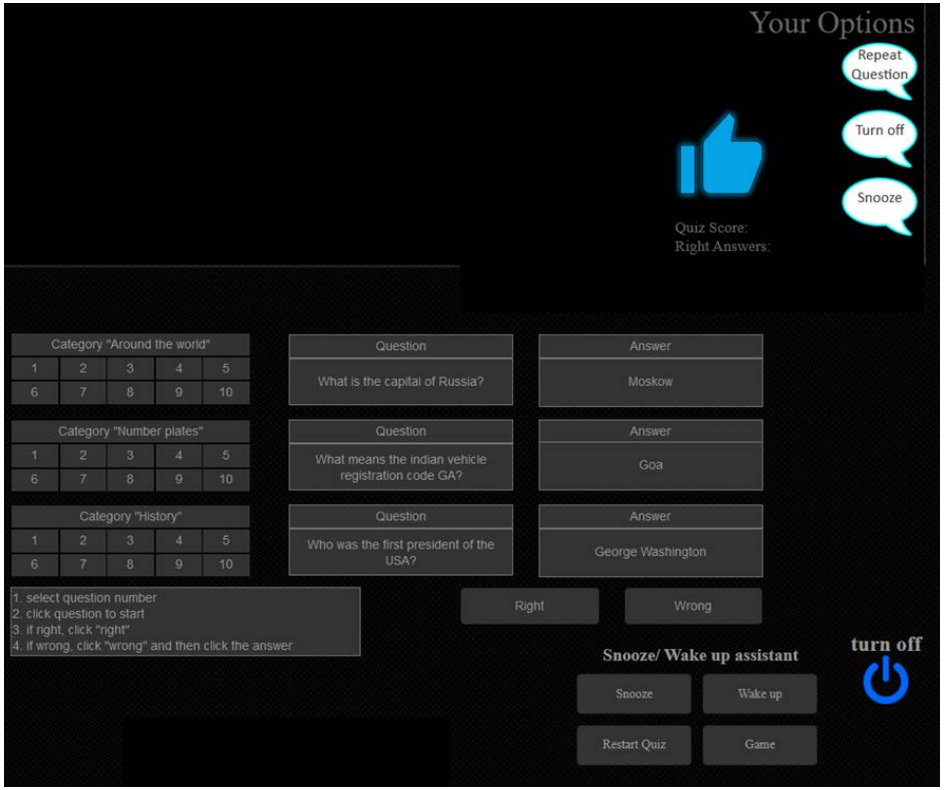


Figure 5.9: Layout quiz

The quiz, implemented in the prototype, is limited with three categories of questions. Each category contains ten questions, which are listed in appendix B. The categories in this prototype are "Around the world", "Number plates" and "History", with which a small spectrum of general knowledge is covered. The quiz is conceptualized as a dialogue between the assistant system and the driver. The questions are presented to the driver as audio output only. As explained in chapter 4.2, the questions can be answered with maximum three words and there are no answer options given to the driver.

The wizard can watch a question by clicking on the numbered rectangles in the left area. The question, as well as the corresponding answer on the right, appear on click. To activate the audio output of the question, the wizard must click on the appropriate question rectangle. The question can be repeated as often as the driver wants by clicking the question rectangle again.

If the driver gives the right answer, the wizard must click on the "right" button, which implements the audio output: *"Super! That's right!"* and the *thumb up* is shown for five seconds. Correct answers are counted and the actual percentage of them is shown on the LCD. So, the driver's ambition should be activated and the monotony of the driving task should shrink. In case of a wrong answer of the driver must click on the rectangle containing the answer. Then the following is played: *"That's wrong. The right answer is…"*

The quiz can be snoozed and the following interaction possibilities are listed in in figure

Table 5.11: Dialogue states for quiz

State	Decision	Responses
Quiz is active	-	"Snooze" and "Turn off"
Assistant is snoozing	-	"Wake up" and "Turn off"
Assistant woken up	"What's next?"	"Restart Quiz" and "Game"

Unfortunately, it is not possible to continue the quiz after the snooze-mode, because the statistics are refreshed with the restart of the quiz.

5.6 Implementation in *Axure*

In the following, the implementation of characteristic features of the prototype in *Axure* is explained. Such features might need an iteration after first tests-rows in the driving simulator of IAD. This is explained in detail in chapter 7.2. To facilitate an iteration, the used *Axure*-features are documented.

Audio files

As already mentioned in chapter 2.5., audio files can be integrated as a link to an external website. The Axure-feature *inline frame* opens a link within the current page. To add an audio output for example another question, the following steps must be done to integrate the audio file into the *Axure* prototype:

1. Creating the text of the audio
2. Copying and pasting the text to *fromtexttospeech.com* to create an audio file
3. Download the audio file
4. Upload with the hosting tools *Hostinger* on the website *http://www.wozprototype.esy.es*, by using *FileZilla* as shown in Figure 5.10: Hosting with *FileZilla*:

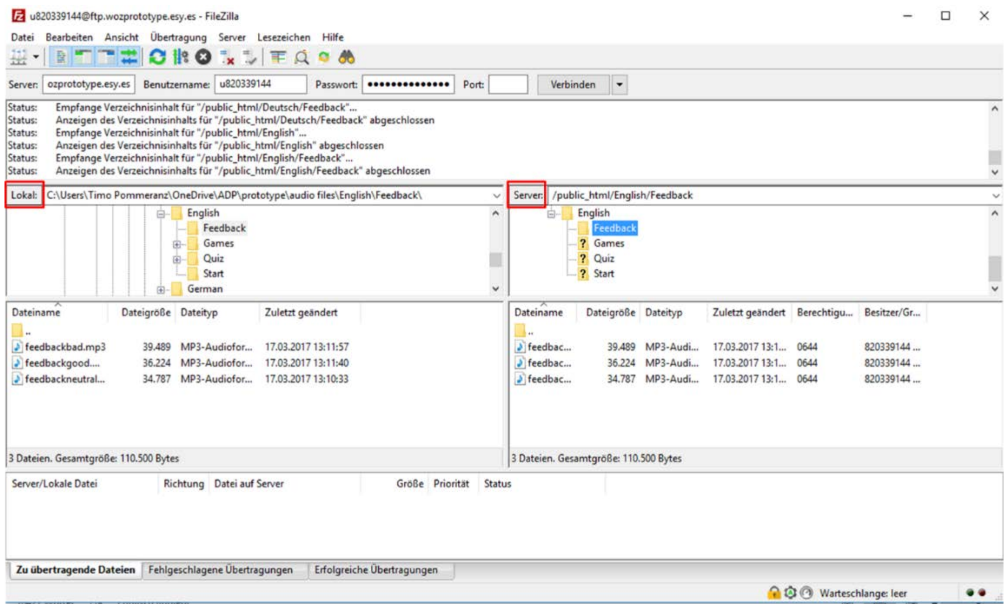


Figure 5.10: Hosting with *FileZilla*

5. Open *http://www.wozprototype.esy.es* and open the sought audio file
6. Copy the URL as shown in Figure 5.11

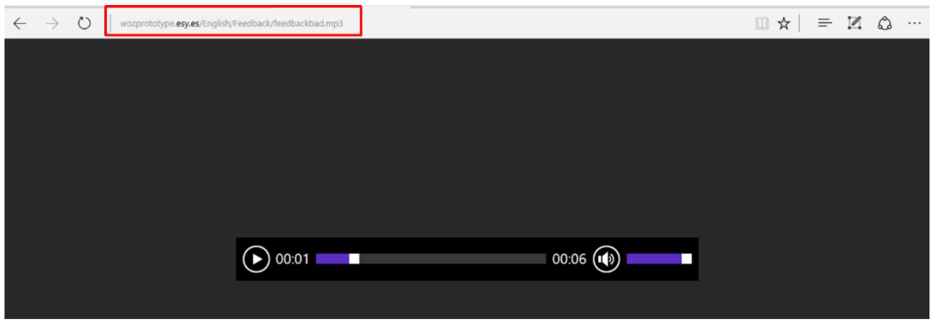


Figure 5.11: URL of audio file

7. Choose the element, which triggers the audio output in *Axure* and add a case with the *case editor*

8. Choose the option *open link in inline frame* and paste the link as shown in Figure 5.12

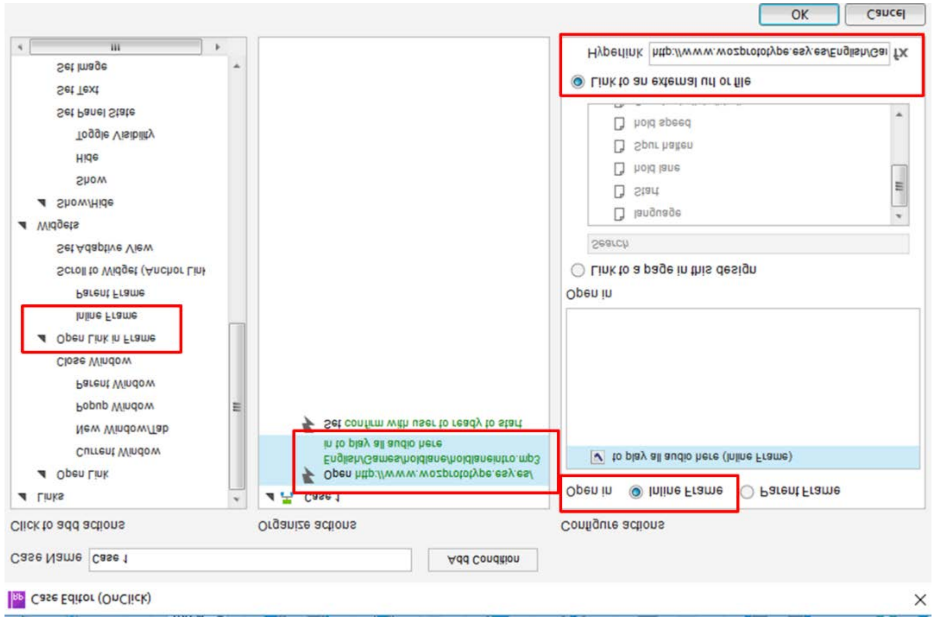
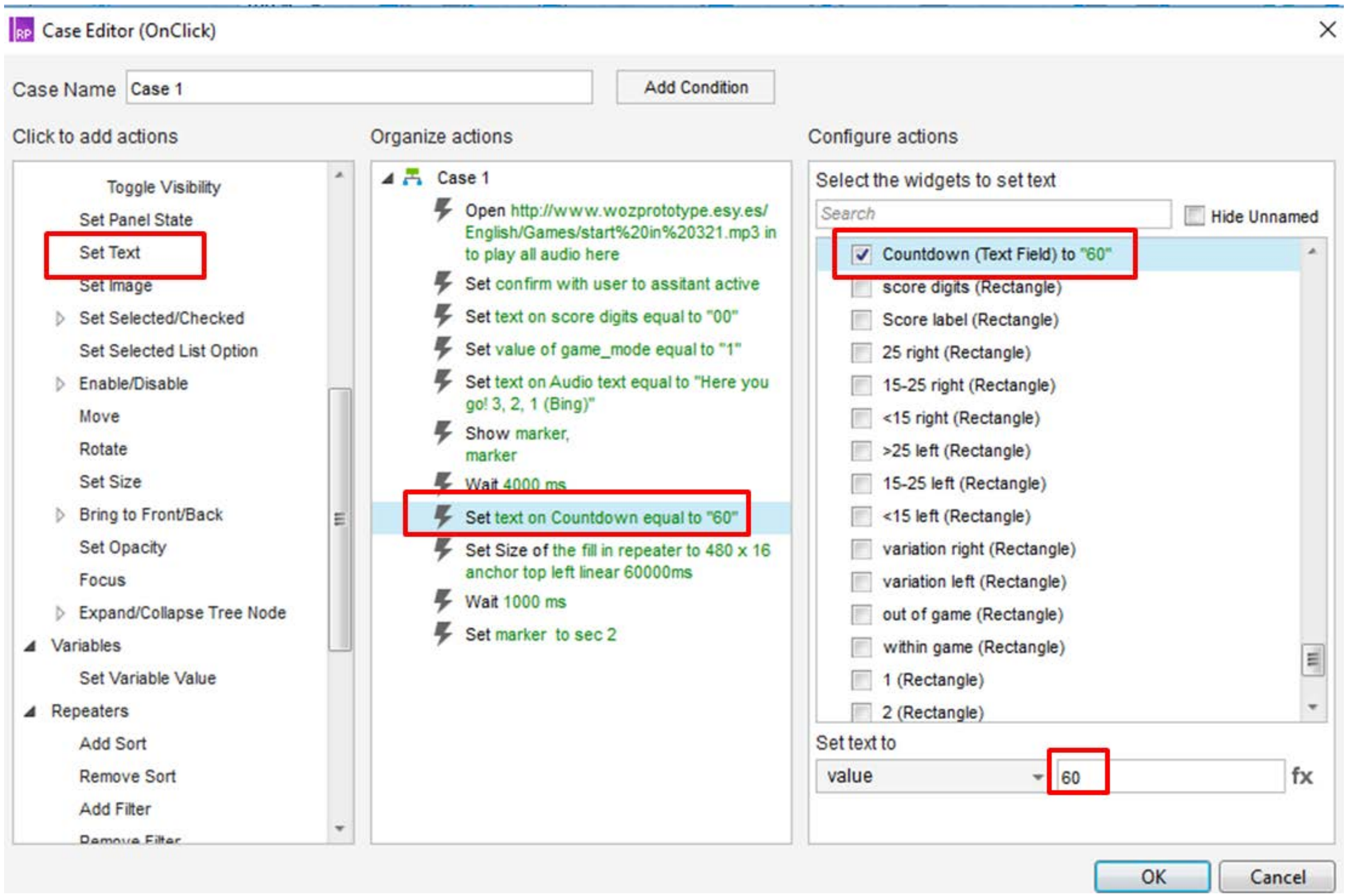


Figure 5.12: *Case editor* for audio files

Countdown and game duration

To trigger the countdown, the start-button sets the text on the countdown to 60. The countdown is realised with the feature *OnTextChange*. Clicking the start-button starts a loop: After every second the value of the digit is set one less than before. To change the starting point of the countdown, the start button has to set the text of the countdown to the requested starting point. Next to the countdown, the game duration is visualized on the HUD with a filling rectangle. The start-button triggers the filling process too. The *case editor* for the start button is shown in


Case Editor (OnClick)
Case Name
Case 1
Add Condition
Click to add actions
Toggle Visibility
Set Panel State
Set Text
Set Image
Set Selected/Checked
Set Selected List Option
Enable/Disable
Move
Rotate
Set Size
Bring to Front/Back
Set Opacity
Focus
Expand/Collapse Tree Node
Variables
Set Variable Value
Repeaters
Add Sort
Remove Sort
Add Filter
Organize actions
Case 1
Open http://www.wozprototype.esy.es/English/Games/start%20in%20321.mp3 in to play all audio here
Set confirm with user to assitant active
Set text on score digits equal to "00"
Set value of game_mode equal to "1"
Set text on Audio text equal to "Here you go! 3, 2, 1 (Bing)"
Show marker, marker
Wait 4000 ms
Set text on Countdown equal to "60"
Set Size of the fill in repeater to 480 x 16 anchor top left linear 60000ms
Wait 1000 ms
Set marker to sec 2
Configure actions
Select the widgets to set text
Search
Hide Unnamed
Countdown (Text Field) to "60"
score digits (Rectangle)
Score label (Rectangle)
25 right (Rectangle)
15-25 right (Rectangle)
<15 right (Rectangle)
>25 left (Rectangle)
15-25 left (Rectangle)
<15 left (Rectangle)
variation right (Rectangle)
variation left (Rectangle)
out of game (Rectangle)
within game (Rectangle)
1 (Rectangle)
2 (Rectangle)
Set text to
value
60
fx
OK
Cancel

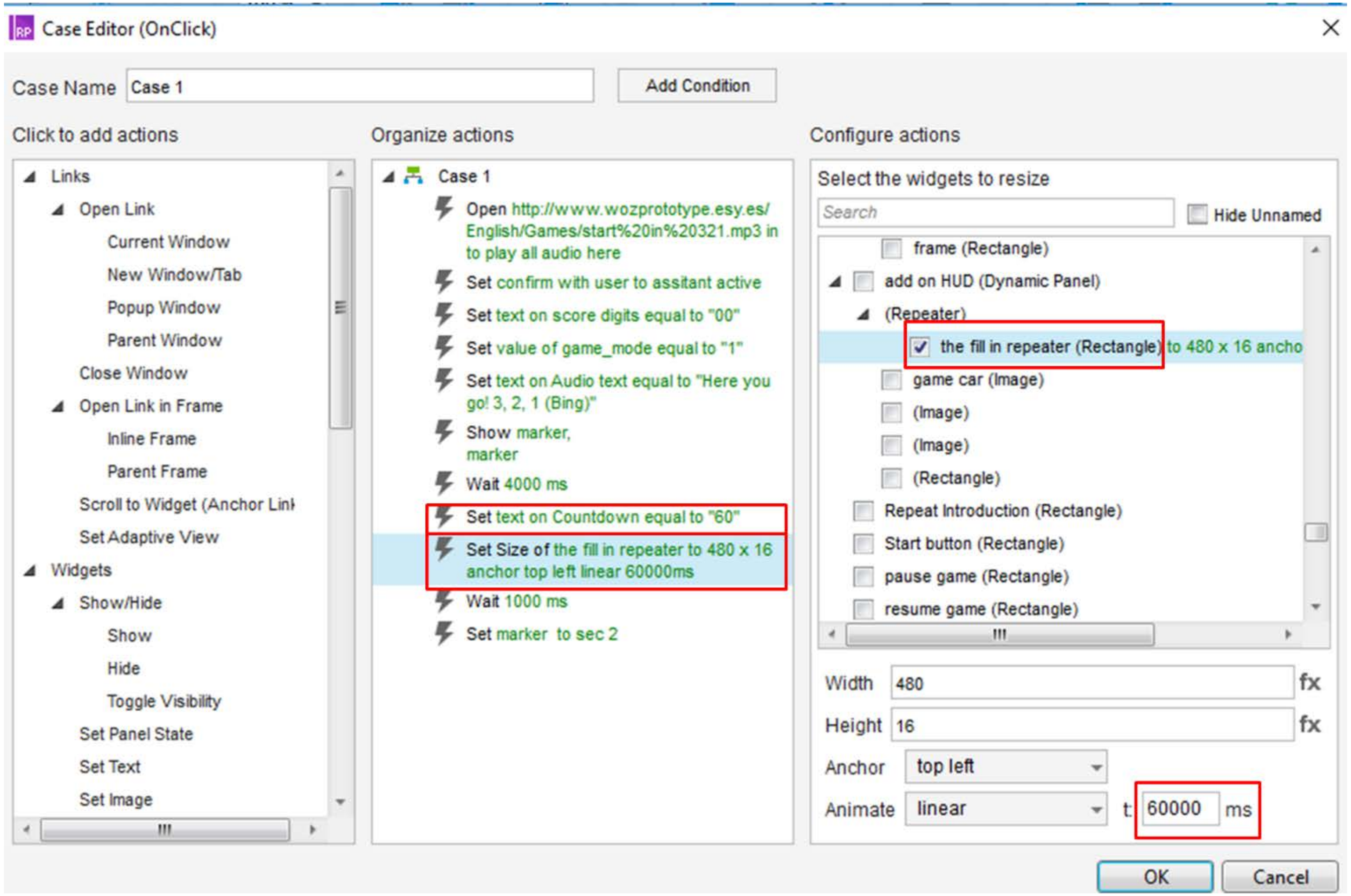
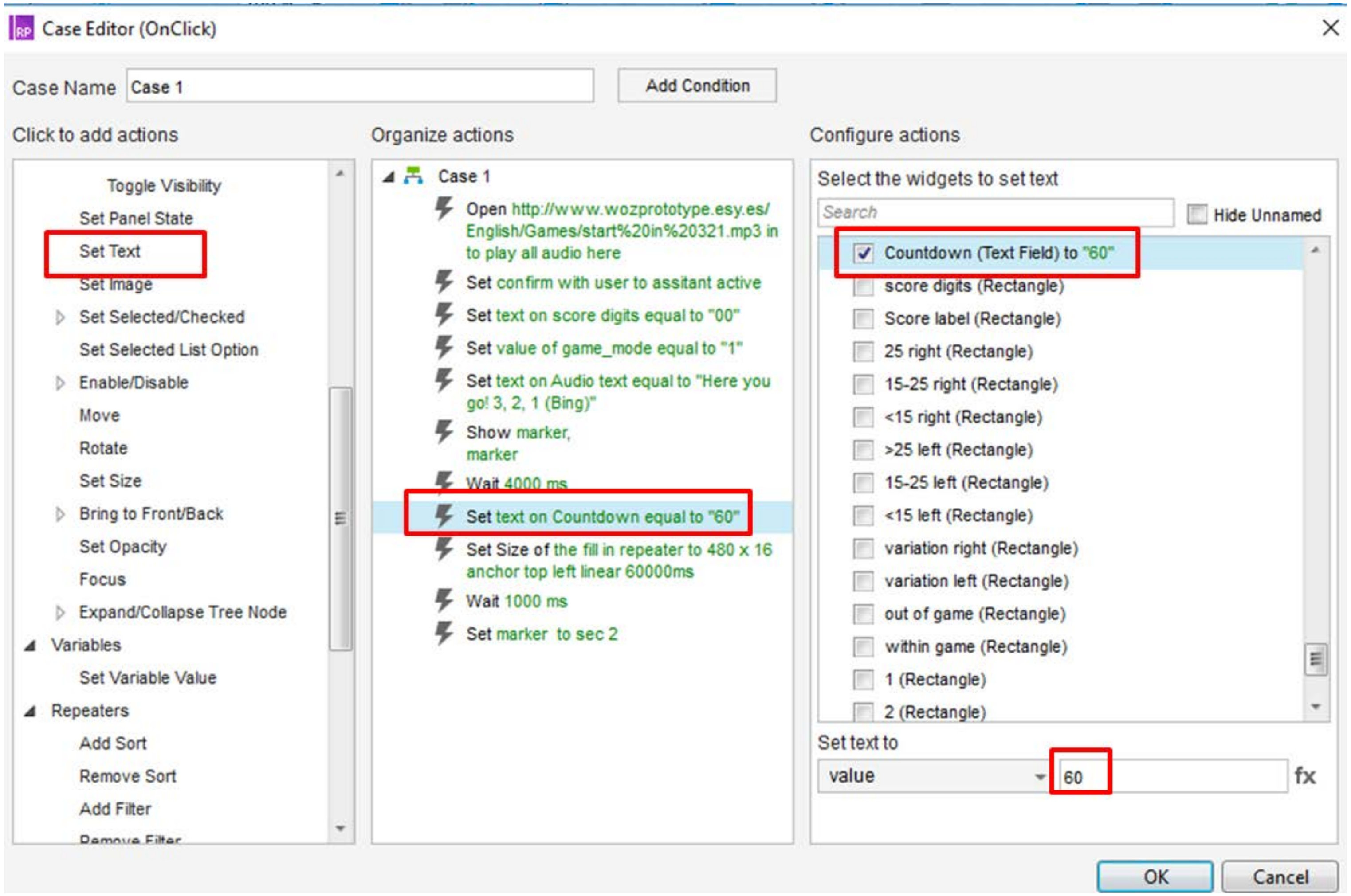


Figure 5.13 twice, to illustrate both processes.



Case Editor (OnClick)
Case Name
Case 1
Add Condition
Click to add actions
Toggle Visibility
Set Panel State
Set Text
Set Image
Set Selected/Checked
Set Selected List Option
Enable/Disable
Move
Rotate
Set Size
Bring to Front/Back
Set Opacity
Focus
Expand/Collapse Tree Node
Variables
Set Variable Value
Repeaters
Add Sort
Remove Sort
Add Filter
Organize actions
Case 1
Open http://www.wozprototype.esy.es/English/Games/start%20in%20321.mp3 in to play all audio here
Set confirm with user to assitant active
Set text on score digits equal to "00"
Set value of game_mode equal to "1"
Set text on Audio text equal to "Here you go! 3, 2, 1 (Bing)"
Show marker, marker
Wait 4000 ms
Set text on Countdown equal to "60"
Set Size of the fill in repeater to 480 x 16 anchor top left linear 60000ms
Wait 1000 ms
Set marker to sec 2
Configure actions
Select the widgets to set text
Search
Hide Unnamed
Countdown (Text Field) to "60"
score digits (Rectangle)
Score label (Rectangle)
25 right (Rectangle)
15-25 right (Rectangle)
<15 right (Rectangle)
>25 left (Rectangle)
15-25 left (Rectangle)
<15 left (Rectangle)
variation right (Rectangle)
variation left (Rectangle)
out of game (Rectangle)
within game (Rectangle)
1 (Rectangle)
2 (Rectangle)
Set text to
value
60
fx
OK
Cancel

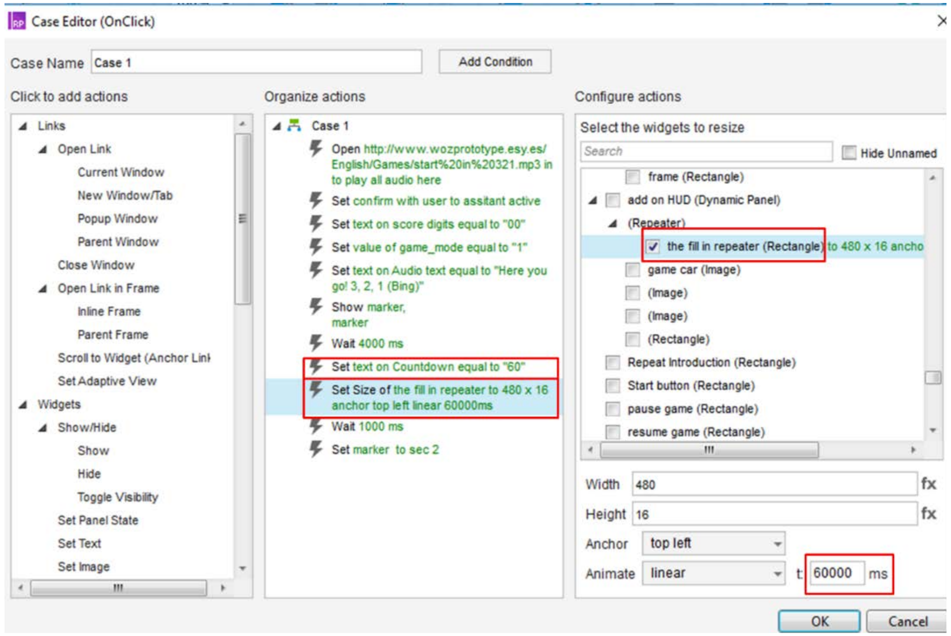


Figure 5.13: *Case editor* start-button

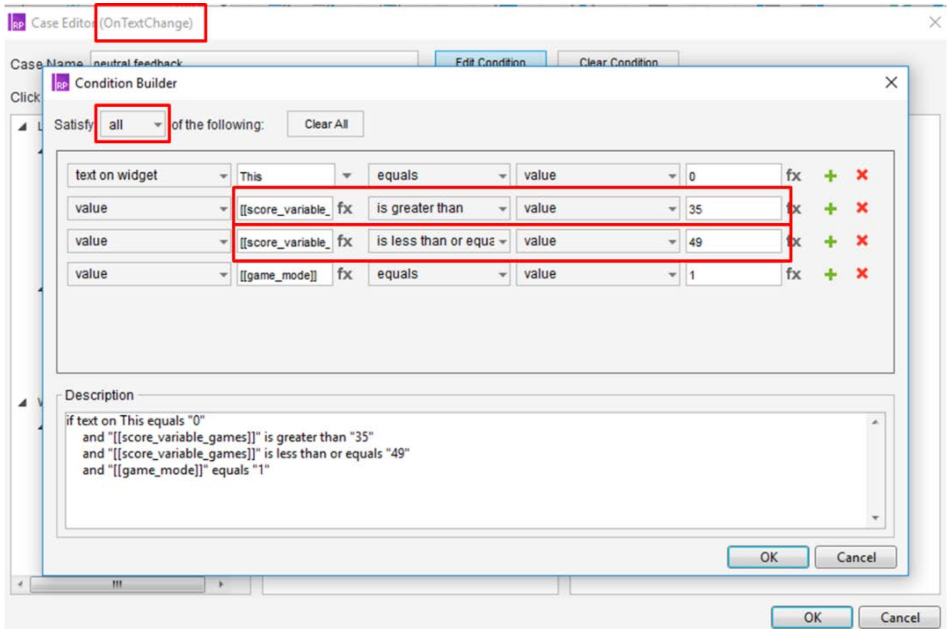


Figure 5.14: *Condition builder* for feedback

Feedback conditions

Depending on his or her performance in a game, the driver gets a visual and an oral feedback afterwards. The score-ranges are listed in chapter 5.4.2 It is implemented in *Axure* with the feature *OnTextChange* and specific conditions about the score. If the text of the countdown is "0", the feedback gets triggered. Depending on the value of the score the feedback is good, neutral or bad. The score range for every feedback is implemented with the *condition builder*, which is shown in for the neutral feedback. With the *condition builder*, the ranges can be changed intuitively.

Scoring

As already explained in chapter 5.4.2, clicking on a rating button changes the score of the driver. Depending on the behaviour, the score gets raised about +1, +2 or +3. This score is implemented in *Axure* with a *global variable*, called *score_variable_games*. Clicking a rating-button, changes this variable and sets the text of the text-field *score* equal to the variable. It is illustrated in Figure 5.15: *Case editor* rating buttons

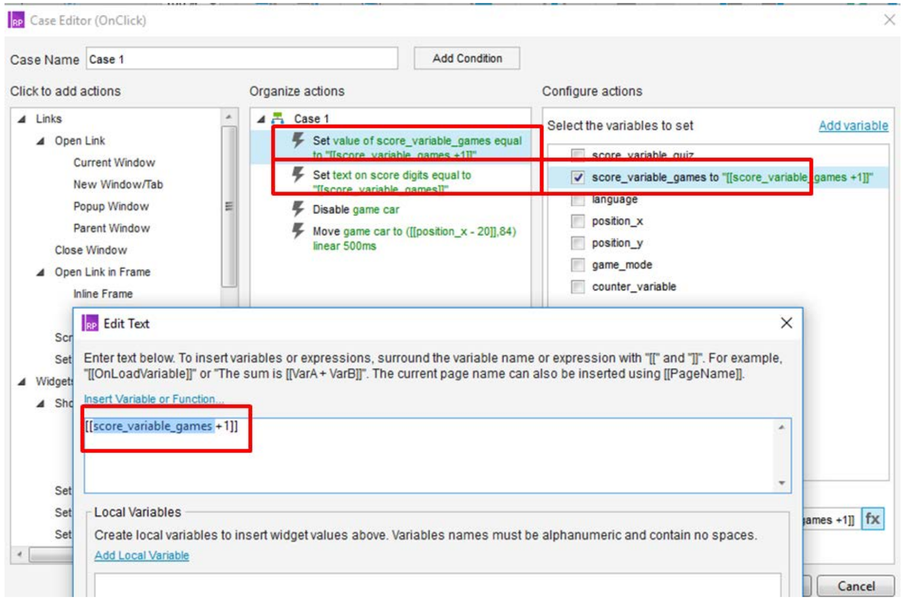


Figure 5.15: *Case editor* rating buttons

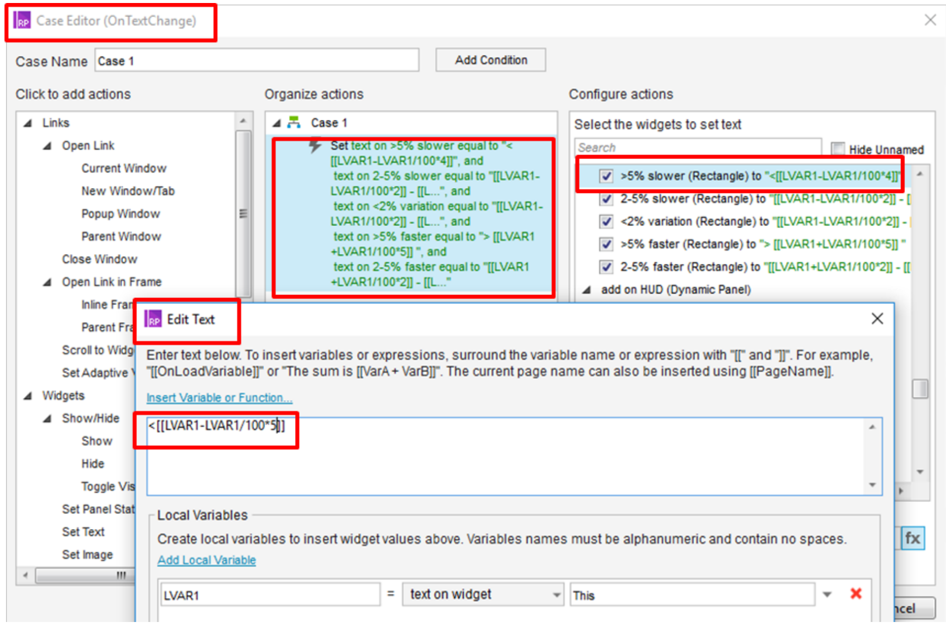


Figure 5.16: *Case editor* game-speed and game-distance

Rating criteria

The text on the rating button represent, the criteria to rate the behaviour of the driver. For the games *holding speed* and *holding distance*, the exact criteria depend on the speed and the distance in the beginning of the game. The text on the buttons is a function of the text-field, where the value of the *game-speed* and the *game-distance* is set. With the *case editor* of this text-field, the criteria can be adjusted. It is shown in Figure 5.16: *Case editor* game-speed and game-distance:

6 Evaluation and Iteration

As described in chapter 2.3, an evaluation, as well as iterating, are part of the human centred design process. The evaluation of the prototype allows to implement the user's experience and requirements in the design process. In the following the evaluation of the prototype is documented. Based on the results of this evaluation, a first round to iterate the prototype is performed and documented in this chapter.

6.1 Evaluation

In the human centered design process the evaluation of the design solutions has the purpose to integrate users' experience in the design process. The evaluation allows for a better understanding of the users' needs by providing new information. The evaluation of the developed prototype can be performed from two different perspectives. The first one is an evaluation of the concept of the assistant system, which is implemented in the prototype. Moreover, this work developed a human computer interface to perform *wizard of Oz-* experiments in the driving simulator of IAD. The evaluation of this work focuses on the evaluation of the experimenter interface, because Amini et al. already evaluated the concept of a gamified co-driver in their work. The results of this evaluation are summarized in the following chapter. Furthermore, it is reflected how these results influence the development of this work.

6.1.1 Evaluation of the Concept

In the following, the main points of the concept's evaluation are listed and reflected. In this project, the evaluation of the previous ADP serves as a reference for the evaluation of our concept. The previous ADP, which resulted in the concept of a gamified co-driver to break monotonous driving situations, performed interviews with three experts from IAD at the Technical University of Darmstadt. The experts from Darmstadt have 1-4 years of experience as researcher at IAD. Two are specialized in vehicle's ergonomics while the third is specialized in usability methods in software development. The results of the evaluation are summarized in the following. The experts state that a HUD helps the driver to keep his eyes on the road. The alert stop feature and a pause feature have been perceived as important. The mostly oral communication reduces the mental load of the driver. All experts evaluate the gamified elements in the concept as a useful countermeasure against drowsiness. However, the evaluation showed that the concept can be improved in terms of its design. In the concept of the previous ADP group, a red thumb down animation is shown as a negative feedback. The negative feedback could lead to a demotivation of the driver and decreases his engagement into using the driving assistance system. Furthermore, the experts state that the games could interfere with the actual driving scenario, especially in the game *Hold the Distance*, in which an interaction with other drivers is required. Another source of interference with the actual driving scenario could be the visualization on the HUD. In order to prevent a distraction of the driver, the HUD is supposed to show as little information as possible. The use of the oral communication instead of the visual information on the HUD is favoured by the experts. However, the experts identify the communication system as part of the operating system as a problem especially for older drivers who are not familiar with the latest technologies. Regarding the games, several suggestions are given by the experts. Firstly, cancellation criteria should be introduced in the game *Hold the Distance* to avoid dangerous situations. The cancellation criteria should protect the driver from himself in case of hazardous driving behaviour due to a chance of being rewarded. One expert questioned the signification of the game *Hold the Distance*, since the driver's concentration to hold the distance to another vehicle can reduce his reaction time. Another cancellation criterion should be introduced for the game *Hold the Speed*. It should prevent that the game continue when the driver changes the lane. Finally, one expert states that 60 seconds per game may be too long. It could lead to monotony within the duration of the game.

To summarize, it can be stated that the experts give positive opinions of the driving assistant system as a countermeasure for monotonous situation. With the help of the evaluation of the previous ADP, the presented project resulted in a realisation of a prototype in which the works of the previous ADP are taken into account.

6.1.2 Evaluation Setup

In contrast to the work of Amini et al., the evaluation of the prototype, which was developed in the presented work, has been performed with potential future users of the prototype. An evaluation in the driving simulator of IAD is not possible for this work's purpose, because it was completed at IIT Bombay in India, where a driving simulator was not available. Nevertheless, the track design was usable with a laptop. For this reason, the evaluation is only made in a reproduced user context of the experimenter. Thereby the main task for the test-experimenter does not change at all, but it must me distinguished an interaction with a potential test driver from the experimenter role. As explained in chapter 5.3 and 5.5, the driver is able to communicate with the assistant system by voice during the start procedure and the quiz feature. Especially for the quiz feature an oral communication between driver and assistant system is necessary. During the start procedure and during the quiz a potential test driver has no other task next to the interaction with the assistant system except the driving. The task of the experimenter is to react on the voice input of the driver and click on the corresponding buttons of his interface. To simulate such a situation, the following conditions are set up:
One person simulates a test a driver and has the task to communicate with the assistant system during the start procedure and the quiz. Instead of a driving task in a driving simulator the person uses *Silab* on a laptop. The test-experimenter is placed in the background without visual contact, but still in a certain distance, to be able to hear the voice of the "driver". That simulates the context of use for the experimenter in the driving simulator of IAD, as described in chapter **Error! Reference source not found.**.
Next to the features mentioned above, the experimenter must be able to handle the game features of the prototype. In the context of this work it is not possible to get the data output on current driving data as speed, distance to the vehicle ahead or lane position, from the simulator software. In case of the evaluation the output does not come from the simulator software. Instead there is a programmed output, which is visualised by *Axure*. This output is shown to the test-experimenter, who uses the prototype of this work. The principle is clarified in Figure 6.1: Evaluation setup

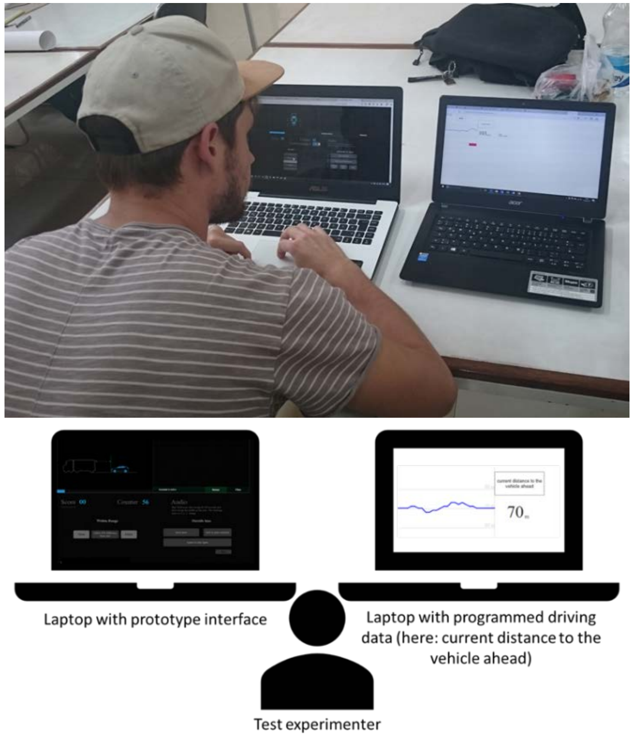


Figure 6.1: Evaluation setup

The programmed driving data includes a scenario, which makes the experimenter pause the game. The programmed data for the game *Holding Lane* is shown in Figure 6.2:

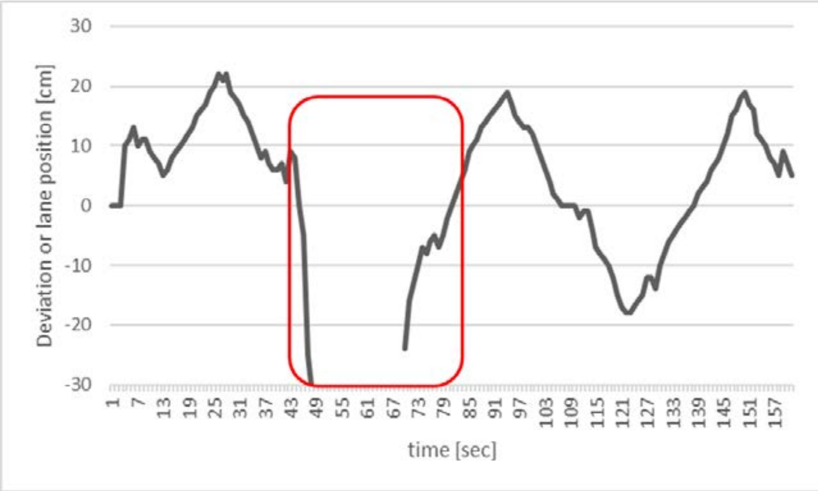


Figure 6.2: Programmed evaluation input

The highlighted area simulates a lane change of the driver, which makes the driver pause the game. In this area, the deviation from the ideal lane position is unlimited. After around 40 seconds the driver is back in a gaming scenario and the experimenter needs to act as explained in chapter 5.4.4. Thus, all features of the prototype concerning the experimenter are included into the evaluation.

Following the experiments, the participants were asked questions about the interface, the games and the task of the *Wizard of Oz-* experimenter. The evaluation questions were asked to understand the requirements of the *Wizard of Oz-* experimenter. The protocols can be found in the appendix. For the evaluation, 5 students participated. Two of the participants are German male students from the Technical University of Darmstadt. They tested the German interface with the German audio output. The other three participants are Indian design students from IIT Bombay including two male and one female. Each participant is a student around 24 years and sufficient knowledge of nowadays technology is assumed. The test procedure took around 15 min. with a 10-min. questioning phase right afterwards.

6.1.3 Results

The feedback to the prototype is in mainly positive with some weaknesses revealed by the evaluation of the questions. The participants highlighted the simplicity of the interface and its straightforwardness. According to the participants, it is suitable for *WOZ* experiments. At the time of the evaluation, the prototype still had some bugs left. Moreover, due to the variety of actions which can be done within the prototype, most of the participants asked for a short instruction or a manual for the first time of use. After the instruction, they reported, the interface and the full range of actions were simple to handle. Another strength of the prototype is that it can be interrupted when needed. One participant suggested to implement an additional alarm button for interrupting the game in case of a dangerous situation. However, when another participant was asked about an additional alarm button, the participant rated it unnecessary because the interface already provided a stop button. Among all the students, four students suggested a personalization of the prototype. By introducing an avatar for the prototype the driver might get more familiar with it. Additionally, an avatar would improve the overall impression of the design which is not vivid. Two of the participants noted, that the prototype might not help in a traffic jam. Other than that, the prototype helped in any monotone driving situation the participants could think of. Another weakness is the three second loop for evaluating the driving behaviour of the test driver during the driving games. Three participants suggested a signal, either an acoustic or a visual signal, to signalise the *WOZ*-experimenter when to rate the driver. The duration of the loop could only be handled with a further help, otherwise the task was tiresome and the evaluation of the driving behaviour was inaccurate. One participant stated that the time of rating was too short.

All participants felt the simultaneous work of looking up the driving data on one screen and clicking on the right rating as difficult, because the *WOZ*-experimenter also has to keep also an eye on the timing, which is only indicated by a counter. Referring to this, one of the design students suggested that the click based interface was not suitable for the WOZ-experimenter. Instead of clicking on the right rating, the rating could be based on an input via the keyboard. For the different types of rating, one button on the keyboard is assigned. Hence, the WOZ-experimenter does not have to search for the right rating on the screen. The suggestion might help him to save time and reduces the work load of the WOZ-experimenter. The participants were further asked about the difficulty of the quiz. Two of the participants questioned whether the mental load for the driver may be too high during the quiz. One of them suggested response possibilities to reduce the mental load. Furthermore, one participant proposed that the questions should not be too long and difficult because the driver's motivation might decrease. Furthermore, an audio feedback for the experimenter when clicking on the *wrong* button was suggested to give the WOZ-experimenter a feedback.

6.2 Iteration

During the iteration process, the results of the evaluation are taken into account and changes on the prototype are made. Firstly, an avatar is introduced into the design of the prototype. It helps to familiarize the driver with the driving assistance system and improves the overall impression of the interface. Depending on the input of the driver, the avatar is active or snoozing. The different states of the avatar are shown in Figure 6.3: Avatar. The new interface with the avatar is shown in Figure 6.4: Iterated interface

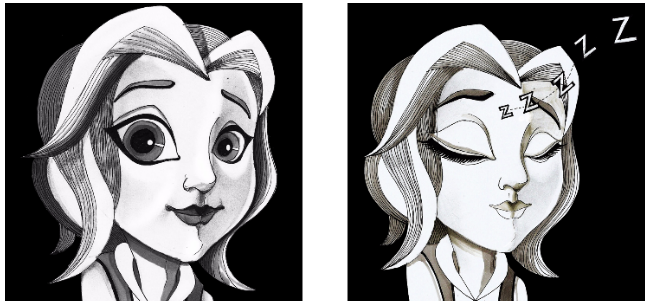


Figure 6.3: Avatar

For the WOZ-experimenter, one major change on the interface is made. A visual reference for the time of rating is implemented. The visual reference helps to rate the driver correctly and reduces the workload. Furthermore, the task of the experimenter is more understandable due to the visual frame. The iterated interface with the avatar and the visual reference is shown in Figure 6.4: Iterated interface:

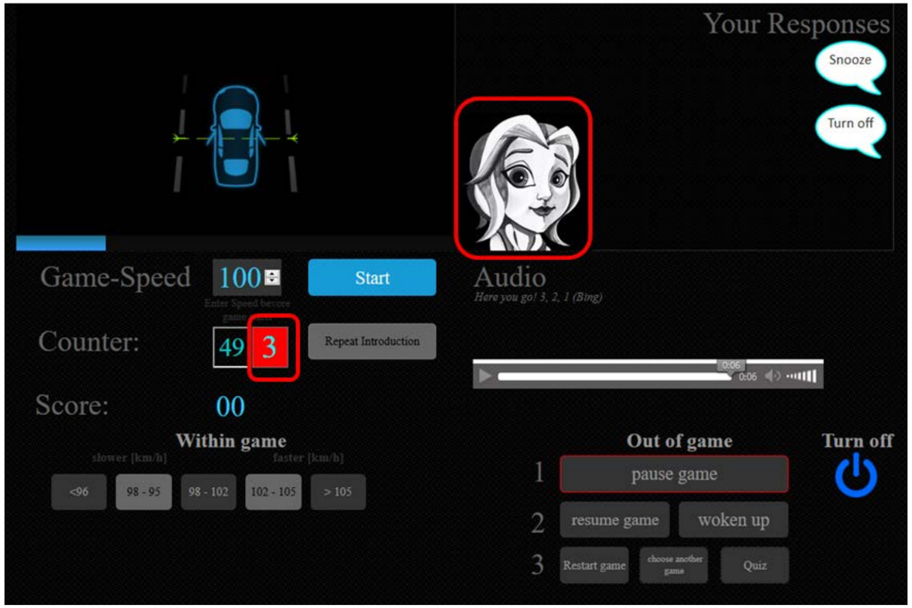


Figure 6.4: Iterated interface

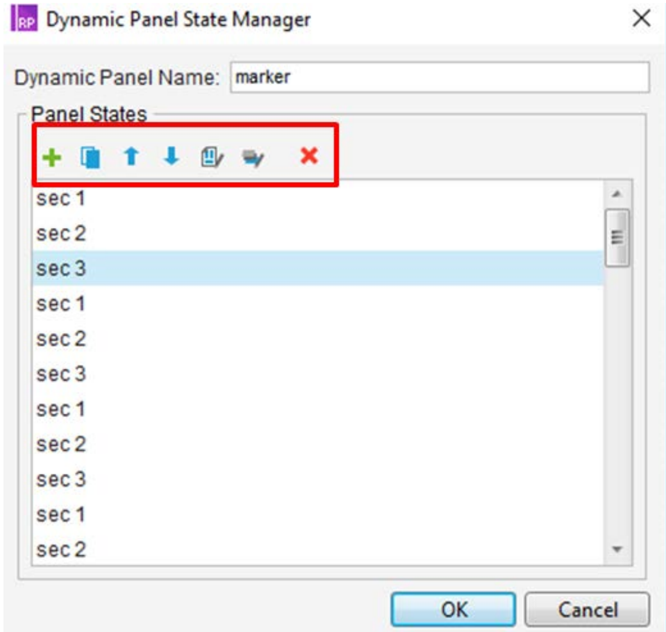


Figure 6.5: *Dynamic Panel State Manager* of the visual reference

As explained in chapter 5.4.2, the time for the experimenter for one rating of the driver is three seconds. This time might be adjusted. In this case, the visual reference must be adjusted in *Axure* as well. It is realized with a *dynamic panel*. By clicking the start button, the *panel state* is changed and a process of 60 *state-changes* is started. To change the visual reference, states can be added or deleted with the *Dynamic Panel State Manager*, which is shown in Figure 6.5: *Dynamic Panel State Manager* of the visual reference

7 Conclusion and Outlook

The essential work of this ADP is summarized in the following chapter. Furthermore, the usefulness of the developed prototype in the context of a driving simulator is shown in an outlook. It is also shown which features can potentially be implemented in a real system, which is used in a real car instead of a driving simulator.

7.1 Conclusion

The concept of a virtual co-driver with gaming elements has been already developed in the works of Amini et al, and (Hieronymus et al.. Considering the results of the present project, this concept can be tested in the driving simulator of IAD within *Wizard of Oz*"-experiments. This work supplies the essential feature to perform these experiments. The *Axure* interface, which was developed in this ADP, makes it possible for the experimenter to simulate an assistant system which reduces the monotony for the driver during long drives in a monotonous environment.
Three output channels are used for the communication between driver and simulated assistant system:

- A HUD, which is represented by a smartphone, located on the board right in front of the windscreen of the simulator car where the content of the display is mirrored.
- A LCD, which is represented by a tablet. This tablet is located on the centre console of the car.
- Audio Output

The interface of the *Axure* prototype shows the content of the two displays and the audio as well. To interact with the simulated assistant system, the driver can use his voice.
As already conceived in the previous ADP of Amini et al, three driving games are implemented into the assistant system. The **Axure** prototype makes it possible to play these games in the context of a driving simulator. Each game challenges the driver in another way:

- Holding lane: The driver must drive along the middle of his lane exactly for 60 seconds
- Holding speed: The driver must continuously hold his speed for 60 seconds.
- Holding distance: The driver must hold a certain distance to the vehicle in front for 60 seconds

After finishing a game the driver gets a feedback, on the score, which depends on the rating of the user of the *Axure* prototype. The experimenter rates the behaviour of the driver during the game every three seconds and presses a rating button, depending on driving data he gets from the driving simulator software.
In addition to the three driving games a Quiz feature is implemented into the *Axure* prototype. With this feature the driver can be asked up to 30 different questions during driving, which also breaks the monotony of the driving task.
The interface of the *Axure* prototype is in English language and can also switched to German language.
After the *Axure* prototype was developed it was evaluated by potential users. The evaluation concentrated on the user interface of the *Axure* prototype. The concept of a gamified assistant system to reduce monotony in general has already been evaluated by Amini et al. Their results were already implemented when developing the *Axure* prototype. As a result of the evaluation some features are added to the prototype to raise its usability.

7.2 Outlook

As explained in the previous chapter, the *Axure* prototype can be used in the driving simulator to perform *WOZ*-experiments. The purpose of these experiments is to validate the concept of an assistant system which breaks the monotony for the driver. It needs to be investigated if the driving task

is compatible with the tasks that arise by using the assistant system. Especially the feedback, which is given to the driver during games in the HUD, must be investigated critically.
Next to the compatibility with the driving task, the experiments must investigate the effect of reducing monotony of the driver by using this system. With the quiz feature, reference data on the effect of reduced monotony can be collected and compared to the effect of the driving games.
Some features of the assistant system can only be investigated by performing experiments in the driving simulator. As an example, it must be investigated if the duration of the games is suitable. If not, the duration must be adjusted. Next to the duration, the crating criteria must be questioned basing on the results the test drivers achieve in the experiments. A balanced amount of good, neutral and bad results should be strived.
Another point to investigate is, the practicability of the games in a driving scenario with other road users. Especially those games, that challenge the driver to hold the distance to the vehicle in front and to hold the speed, can be significantly influenced and interrupted by other road users. Only experiments can show if these challenges are doable in road traffic.

In the long-term, some features of the system will be different compared to the developed *Axure* prototype. The most significant point is, that the feedback during a driving game can be improved noticeably. Driving data like speed or the position in the lane can be processed without time delay, which will improve the performance and the acceptance of the driver. The quiz feature as well has much potential to be improved. More questions, more categories and different levels of difficulties can be implemented. Furthermore, data and results of game or quiz performances can be saved and used to create statistics. This is an essential point to maintain the ambition of the driver to use the assistant system.

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List of Abbreviation

ADP	Advanced Design Project
ARP	Advanced Research Project
HUD	Head-up Display
LCD	Liquid Crystal Display
WOZ	Wizard of OZ
OBD	On-Board Diagnostics

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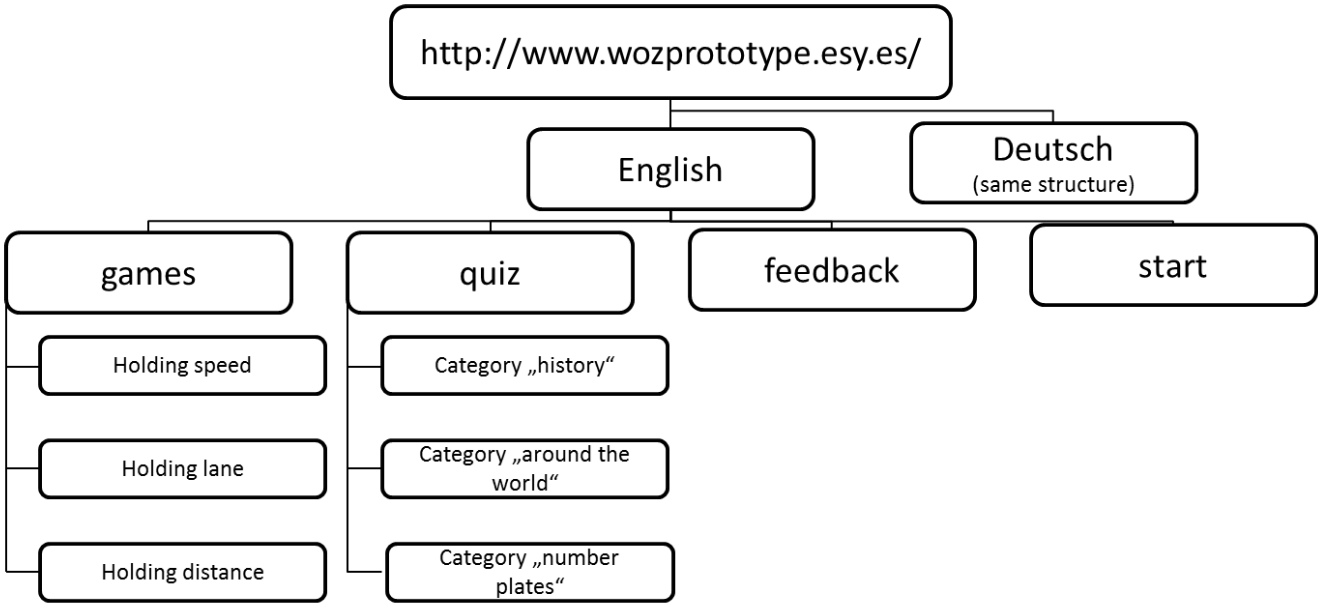
A Access data for Gmail and Hostinger and structure of the audio register

Access data *Gmail*

Account name	WOZprototype@gmail.com
Name of Owner	ADP IAD
Date of birth	01.01.1990
sex	male
password	IAD.TU-Darmstadt

Access data *Hostinger*

Account name	ADP IAD
password	IAD.TU-Darmstadt
Hosting website	http://www.wozprototype.esy.es



B List of texts and questions

Audio texts

scenario/butt-on	text english	link english	text german	link german
start procedure				
1 monotounous situation detected	Monotonous driving situation detected. Would you like me to assist you?	http://www.wozprototype.esy.es/English/Start/monotonydetected.mp3	Monotone Fahrsituation erkannt. Möchtest du, dass ich dir assistiere?	http://www.wozprototype.esy.es/Deutsch/Start/monotone%20Fahrsituation%20erkannt.mp3
2 driver agrees	Nice! Would you like to play a game or a quiz?	http://www.wozprototype.esy.es/English/Start/gameorqiz.mp3	Sehr schön. Würdest du lieber ein Spiel oder ein Quiz spielen?	http://www.wozprototype.esy.es/Deutsch/Start/spieloderquiz.mp3
3 game selection	Good choice! Which game would you like to play? You can either challange yourself to maintain your lane, speed or distance.	http://www.wozprototype.esy.es/English/Start/lane,%20speed%20or%20distance.mp3	Gute Wahl! Welches Spiel möchtest du spielen? Du kannst dich selbst herausfordern durch das Halten der Spur, der Geschwindigkeit oder dem Abstand zum vorrausfahrenden Fahrzeug.	http://www.wozprototype.esy.es/Deutsch/Start/spielauswahl.mp3
games in general				
start game	Here you go! 3, 2, 1 (Bing)	http://www.wozprototype.esy.es/English/Games/start%20in%20321.mp3	Los geht's in 3, 2, 1, (Bing)	http://www.wozprototype.esy.es/Deutsch/Spiele/los%20gehts%20in%20321%20.mp3
game paused	Game paused	http://www.wozprototype.esy.es/English/Games/game%20paused.mp3	Spiel unterbrochen	http://www.wozprototype.esy.es/Deutsch/Spiele/Spiel%20unterbrochen.mp3
restart game after pause	Are you ready to restart the game?	http://www.wozprototype.esy.es/English/Games/ready%20to%20restart.mp3	Bist du bereit das Spiel neu zu starten?	http://www.wozprototype.esy.es/Deutsch/Spiele/bereit%20neu%20zu%20starten.mp3

holding lane				
intro	Hey! Hold your lane steady for 60 seconds and drive along the middle of the lane. Do you want to hear the introduction one more time or are you ready to start?	http://www.wozprototype.esy.es/English/Games/holdlane/holdlaneintro.mp3	Hey! Halte exakt deine Fahrspur und fahre genau entlang der Spurmitte. Möchtest du die Einleitung noch einmal hören oder bist du bereit das Spiel zu starten?	http://www.wozprototype.esy.es/Deutsch/Spiele/Spurhalten/Spurhaltenintro.mp3
back in the lane	OK. You are back in the lane. Would you like to play again? Otherwise you can also play another game or a quiz.	http://www.wozprototype.esy.es/English/Games/holdlane/backinlane.mp3	Ok! Du bist zurück in der Spur. Möchtest du das Spiel wieder starten? Andernfalls kannst du auch ein anderes Spiel oder ein Quiz spielen.	http://www.wozprototype.esy.es/Deutsch/Spiele/Spurhalten/zur%fcck%20in%20der%20Spur.mp3
holding speed				
intro	Let's see if you can hold the same speed continuously for 60 seconds. Do you want to hear the introduction one more time or are you ready to start?	http://www.wozprototype.esy.es/English/Games/holdspeed/holdspeedintro.mp3	Zeige, dass du deine Geschwindigkeit für 60 Sekunden punktgenau halten kannst. Möchtest du die Einleitung noch einmal hören oder bist du bereit das Spiel zu starten?	http://www.wozprototype.esy.es/Deutsch/Spiele/Geschwindigkeithalten/Geschwindigkeithaltenintro.mp3
steady speed again	Ok. You are having a steady speed again. Would you like to play again? Otherwise you can also play another game or a quiz.	http://www.wozprototype.esy.es/English/Games/holdspeed/steady%20speed%20again.mp3	Ok. Du hast wieder eine stetige Geschwindigkeit erreicht. Möchtest du noch einmal spielen? Andernfalls kannst du auch ein anderes Spiel oder ein Quiz spielen.	http://www.wozprototype.esy.es/Deutsch/Spiele/Geschwindigkeithalten/wieder%20stetige%20Geschwindigkeit.mp3

holding distance				
intro	Let's see if you can maintain the same distance with the vehicle in front of you for 60 seconds. Do you want to hear the introduction one more time or are you ready to start?	http://www.wozprototype.esy.es/English/Games/holddistance/holddistance%20intro.mp3	Zeige, dass du den Abstand zum Fahrzeug vor dir für 60 Sekunden genau einhalten kannst. Möchtest du die Einleitung noch einmal hören oder bist du bereit das spiel zu starten?	http://www.wozprototype.esy.es/Deutsch/Spiele/Abstandhalten/Abstandhaltenintro.mp3
steady distance again	Ok. You once again a steady distance to vehicle ahead of you. Would you like to play again? Otherwise you can also play another game or a quiz.	http://www.wozprototype.esy.es/English/Games/holddistance/steady%20distance%20again.mp3	Ok. Du hast wieder einen stetigen Abstand zum vorausfahrenden Fahrzeug. Möchtest du noch einmal spielen? Andernfalls kannst du auch ein anderes Spiel oder ein Quiz spielen.	http://www.wozprototype.esy.es/Deutsch/Spiele/Abstandhalten/wieder%20stetiger%20Abstand.mp3
feedback				
good	That's a good one. Would you like to play again? Otherwise you can also play another game or a quiz.	http://www.wozprototype.esy.es/English/Feedback/feedbackgood.mp3	Das war sehr gut. Möchtest du noch einmal spielen? Andernfalls kannst du auch ein anderes Spiel oder ein Quiz spielen.	http://www.wozprototype.esy.es/Deutsch/Feedback/feedback%20gut.mp3
neutral	Not bad! Would you like to play again? Otherwise you can also play another game or a quiz.	http://www.wozprototype.esy.es/English/Feedback/feedbackneutral.mp3	Nicht schlecht. Möchtest du noch einmal spielen? Andernfalls kannst du auch ein anderes Spiel oder ein Quiz spielen.	http://www.wozprototype.esy.es/Deutsch/Feedback/feedback%20neutral.mp3
bad	You can do better than that. Would you like to play again? Otherwise you can also play another game or a quiz.	http://www.wozprototype.esy.es/English/Feedback/feedbackbad.mp3	Das kannst du besser. Möchtest du nocheinmal spielen? Andernfalls kannst du auch ein anderes Spiel oder ein Quiz spielen.	http://www.wozprototype.esy.es/Deutsch/Feedback/feedback%20schlecht.mp3

LCD status bar after waking up				
for games	Welcome back! Do you want to restart the last game or would you prefer to play another game or a quiz?	http://www.wozprototype.esy.es/English/Games/woken%20up%20from%20snoozing.mp3	Willkommen zurück! Möchtest du das letzte Spiel neu starten oder möchtest du lieber ein anderes Spiel oder ein Quiz spielen?	http://www.wozprototype.esy.es/Deutsch/Spiele/aufgeweckt.mp3
for quiz	Welcome back! Do you want to restart the quiz or would you prefer to play a game?	http://www.wozprototype.esy.es/English/Quiz/woken%20up%20from%20snooze.mp3	Willkommen zurück! Möchtest du das Quiz neu starten oder lieber ein Spiel spielen?	http://www.wozprototype.esy.es/Deutsch/Quiz/aufgeweckt.mp3

Questions of the Quiz

	English		**Deutsch**	
	text	**link**	**Text**	**Link**
Intro-duc-tion	Nice! You will be asked questions out of three random categorys. If you want to hear the question again, say "repeat". To answer, speak your response out lodly. Have fun!	http://www.wozprototype.esy.es/English/Quiz/Start.mp3	Schön! Du bekommst Fragen aus drei zufälligen Kategorien gestellt. Um die Frage nocheinmal zu hören, sage "wiederholen". Um die Frage zu beantworten, sreich deine Antwort laut und deutlich aus.	http://www.wozprototype.esy.es/Deutsch/Quiz/Intro.mp3
Right ans-wer	Super! That's rigth!	http://www.wozprototype.esy.es/English/Quiz/right.mp3	Sehr gut! Das ist richtig!	http://www.wozprototype.esy.es/Deutsch/Quiz/richtig.mp3
	pool of questions		**Fragenpool**	
	Questions	**Answers**	**Fragenpool**	**Antoworten**

	Category "Around the world"		Kategorie "Rund um die Welt"	
Links	http://www.wozprototype.esy.es/English/Quiz/Category%20%22Around%20the%20world%22/	http://www.wozprototype.esy.es/English/Quiz/Category%20%22Around%20the%20world%22/Answers/	http://www.wozprototype.esy.es/Deutsch/Quiz/Kategorie%20%22Rund%20um%20die%20Welt%22/	http://www.wozprototype.esy.es/Deutsch/Quiz/Kategorie%20%22Rund%20um%20die%20Welt%22/Antworten/
1	What is the capital of Russia?	Moskow	Was ist die Hauptstadt Russlands?	Moskau
2	What is the longest river in Pakistan?	Indus	Was ist derlängste Fluss in Pakistan?	Indus
3	Are pinguins typicall for Arktika or Antarktika?	Antarktica	Sind Pinguine typische für Atrktis oder Antarktis?	Antarktis
4	Which famous complex connects the atlantic and the Pacific Ocean?	panama canal	Welche berühmte Anlage verbindet atlantischen und pazifischen Ozean?	Panama Kanal
5	Which sea area is famous for many inexplcable accidents	Bermuda triangle	Welches Seegebiet ist für viele unerklärliche Unglücke bekannt?	Bermuda Dreieck
6	Which famous bridge stands in San Francisco?	Golden Gate Bridge	Für welche Brücke ist San Francisco berühmt?	Golden Gate Bridge
7	In which country lies Patagonia?	Agentina	In welchem Land liegt Patagonien?	Argentinien
8	In which City is the 0th longitude definid?	Greenwich, London	In welcher Stadt ist der 0-te Längengrad definiert?	Greenwich, London
9	Which continets are called the 5th and the 6th continent?	Australia and Antarktika	Welche Kontinete werde als der fünte und der sechste Kontinet bezeichnet?	Australien und Antarktis

10	Which language is spoken in Brazil	Portuguese	Welche Sprache wird in Brasilien gesprochen?	Portugiesisch
	Category "Number Plates"		Kategorie "Nummernschilder"	
Links	http://www.wozprototype.esy.es/English/Quiz/Caterogy%20%22Number%20Plates%22/	http://www.wozprototype.esy.es/English/Quiz/Caterogy%20%22Number%20Plates%22/Answers/	http://www.wozprototype.esy.es/Deutsch/Quiz/Kategorie%20%22Nummernschilder%22/	http://www.wozprototype.esy.es/Deutsch/Quiz/Kategorie%20%22Nummernschilder%22/Antworten/
11	What means the indian vehicle registration code MH?	Maharashtra	Wofür steht das KFZ-Kennzeichen HB?	Hansestadt Bremen
12	What means the indian vehicle registration code GA?	Goa	Wofür steht das KFZ-Kennzeichen BI?	Bielefeld
13	What means the indian vehicle registration code PB?	Punjab	Wofür steht das KFZ-Kennzeichen DO?	Dortmund
14	What means the indian vehicle registration code DL?	Delhi	Wofür steht das KFZ-Kennzeichen KL?	Kaiserslautern
15	What means the indian vehicle registration code KL?	Kerala	Wofür steht das KFZ-Kennzeichen MD?	Magdeburg
16	What means the indian vehicle registration code UP?	Uttar Pradesh	Wofür steht das KFZ-Kennzeichen RO?	Rosenheim
17	What means the indian vehicle registration code NL?	Nagaland	Wofür steht das KFZ-Kennzeichen H?	Hannover

18	What means the indian vehicle registration code AS?	Assam	Wofür steht das KFZ-Kennzeichen KI?	Kiel
19	What means the indian vehicle registration code SK?	Sikkim	Wofür steht das KFZ-Kennzeichen M?	München
20	What means the indian vehicle registration code TN?	Tamil Nadu	Wofür steht das KFZ-Kennzeichen PB?	Paderborn
	Category "History"		Kategorie "Geschichte"	
Links	http://www.wozprototype.esy.es/English/Quiz/Category%20%22History%22/	http://www.wozprototype.esy.es/English/Quiz/Category%20%22History%22/Answers/	http://www.wozprototype.esy.es/Deutsch/Quiz/Kategorie%20%22Geschichte%22/	http://www.wozprototype.esy.es/Deutsch/Quiz/Kategorie%20%22Geschichte%22/Antworten/
21	Who was the first president of the USA?	George Washington	Wer war der erste Präsident der USA?	George Washington
22	What were the names of the founders of Rome according the legend?	Romolus and Remus	Wie hießen der Legende nach die die Gründer der Stadt Rom?	Romolus und Remus
23	Who was the first Person who circumnavigated the world?	Ferdinand Magellan	Wer war die erste Person die die Welt umsegelte?	Ferdinand Magellan
24	When declared India its Independece?	1947	Wann erklärte Indien seine Unabhängigkeit?	1947
25	Where lost Napoleon his last battle?	Waterloo	Wo verlor Napoleon seine letzte wichtige Schlacht?	Waterloo
26	Where was the islamic prophete Mohammed born?	Mekka	Wo wurde der islamische Prohet Mohammed geboren?	Mekka

27	Who was dictator of the Sowjet union between 1927 and 1953?	Joseph Stalin	Wer war Diktaor der Sowjetunion zwschen 1927 und 1953?	Joseph Stalin
28	Who was the first human on top of the Mount Everest?	Edmund Hillary	Wer war der erste Mensch auf dem Mount Everest?	Edmund Hillary
29	Who wrote the drama Romeo and Juliet?	William Shakespeare	Wer schrieb Romeo und Julia?	William Shakespeare
30	Which invention made John Stith Pemberton famous?	Coca Cola	Welche Erfindung machte John Stith Pemberton berühmt?	Coca Cola

C Evaluation protocol

Question 1: What do you think about the level of difficulty of the questions? Is it too low or too high or suitable?

Person 1: The questions are fine but several response possibilities desirable to relieve the driver from too high cognitive load

Person 2: The questions are suitable for the driving tasks.

Person 3: The question may be too difficult which may demotivate the driver, questions should not make up too much time, an audio feedback for the wizard when clicking on the wrong button is necessary

Person 4: The questions are nice because there are different levels of difficulty

Person 5: Some of the questions take too much time to formulate and are really difficult to solve

Question 2: Do you think the prototype is suitable for the task of perform WOZ experiments in a driving simulator?

Person 1: Yes

Person 2: Yes

Person 3: Yes, but click-based which may exhaust the wizard. Rating with the keyboard may help.

Person 4: Yes, there are no difficulties to use the prototype as a WOZ experiment.

Person 5: Yes, the interaction based prototype is suitable to use in a WOZ environment.

Question 3: Is the interface understandable for the experimenter and where do you see probably ambiguities?

Person 1: Short introduction is needed. The interface is easier to work with a mouse.

Person 2: Short introduction is necessary to understand the interface. Working with a mouse is preferable.

Person 3: Easy to understand, however experimenter benefits from a short introduction is preferable.

Person 4: No problem at all. Easy to understand and very straightforward.

Person 5: Short introduction would help to discover all the features of the prototype.

Question 4: Have you been able to operate the interface intuitively?

Person 1: Games were easy to understand but for the quiz an introduction is needed. The possibility to have questions randomly asked would be helpful.

Person 2: A short introduction is necessary.

Person 3: Yes.

Person 4: Yes, the interface and the buttons are straightforward.

Person 5: Yes, naming of the buttons are clear and interface is easy to operate with. However, man features included which are at the beginning a bit confusing.

Question 5: Has the experimenter been able to handle every driving situation, which was simulated during the evaluation during the games?

Person 1: Yes.

Person 2: In traffic jams the prototype is limited to the quiz.

Person 3: Yes., the stop button helps to handle dangerous situation.

Person 4: It may be difficult to use in traffic jams which are monotonous situation, too.

Person 5: Yes, because for dangerous situation there is a stop button.

Question 6: Which scenario could in your opinion also occur and do you think the interface makes it possible to handle?

Person 1: Detection of interruption is difficult. Interruption has to be clearly signed by an alarm button.

Person 2: Traffic jams could cause problems.

Person 3: Other scenarios are pretty much covered by pausing/stopping the game.

Person 4: Traffic jams may be difficult to handle.

Person 5: Most scenarios are covered by the interface.

Question 7: How do you think about the three second loop to rate the behaviour of the driver? Is it too short or could you imagine to rate the behaviour more often than 20 times a minute?

Person 1: 3 second loop is ok but a sign from the interface like a sound or vibration is desirable.

Person 2: There has to be an additional feature to highlight for the 3 second loop otherwise it is difficult to handle with.

Person 3: Click based rating could be difficult because you have to see the button every time and check the driving data within the 3 second loop. A keyboard based rating system would be less difficult to work with

Person 4: 3 second loop might get exhausting when the test will be too long.

Person 5: Within the 60 seconds the 3 second loop is ok but a feedback system for monitoring the 3 second loop would help a lot.

Question 8: How would you rate the error tolerance of the interface?

Person 1: Start-button is necessary otherwise it is low.

Person 2: Error of tolerance is low.

Person 3: Instructions are pretty clear and button are straightforward that is why the error of tolerance is low.

Person 4: Straightforward interface makes the error of tolerance goes to zero.

Person 5: Error of tolerance is quite low because the system is easy to understand.