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Publishable executive summary

Within the AutoDrive project, openPASS¹ is used to develop a cognitive stochastic traffic flow simulation for urban intersections and highway scenarios, which are described in deliverable D1.14.

The deliverable D2.16 includes the customizations of the framework openPASS that are required to provide a basis for the development and implementation of the driver behavior model and the evaluated safety function. The trial design for the evaluation of the safety functions is described. Furthermore, the design of the driver behavior study is introduced to parameterize and validate the underlying driver behavior model.

¹ openPASS is an open source framework for the development of stochastic traffic flow simulations [1]

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1 Introduction

Within the AutoDrive project, openPASS is used to develop a cognitive stochastic traffic flow simulation for urban intersections and highway scenarios, which are described in deliverable D1.14. The cognitive stochastic traffic flow simulation should cover the entire range of traffic events: from normal driving, to critical situations, up to traffic accidents. The basis of the traffic flow simulation is the human driver behavior model. The human driver behavior model depicts the cognitive structures of the driver and represents the human decision making process.

A stochastic simulation approach means that all important driver and vehicle parameters will be chosen by stochastic distribution functions. The distributions are ensured by studies of the Chair of Traffic and Transportation Psychology Dresden (VPSY) and the current state of research. The VPSY is part of the AutoDrive project since December 2018 and is part of the organization Technische Universität Dresden (TUD). Further details can be found in the amendment No. 2 to the grant agreement.

The main focus is on the driver's cognitive structure. The vehicle models are simple point masses and the sampling rate is moderate with an update every 100 milliseconds. Therefore, the simulation time is short and many simulation runs are possible. Simulations with more than 100 000 runs are planned. In this way, the simulation is able to simulate a large part of realistic traffic flow of the entire traffic flow population.

The development of a plausible traffic flow simulation with an underlying cognitive behavior model requires valid driver parameters and a set of validation parameters for the examined traffic situations. The Chair of Automobile Engineering (LKT) and the (VPSY) at the TUD are therefore jointly designing a study to cover these requirements.

The deliverable D2.16 shows the work done on the underlying framework openPASS during the modifications. Furthermore, it includes the design of the parameter and validation studies of the TUD.

Objectives:

The objective of the TUD during the AutoDrive project is the evaluation of selected safety functions of the project partners under the aspect of their impact on road safety. On the basis of the evaluation process, TUD will develop a recommendation for system requirements to guarantee a minimum standard of safety. Also, TUD and the AIT try to develop test cases for the considered safety functions. These test cases are recommendations for possible standardization tests for the evaluation of the corresponding safety functions.

The objectives within the deliverable D2.16 are the adaption of the openPASS framework and the design of the parameter and validation studies.

2 Layout of the traffic simulation

[Contribution: LKT]

This section introduces the underlying simulation framework in general. Firstly, the base framework openPASS is introduced in 2.1 and the core modules (see 2.2) and agent components (see 2.3) are explained. Following, the new added driver behavior modules (see 2.5) and the adjustments on the base framework (see 2.4) are shown.

2.1 Framework OpenPass

Currently, a lot of different software solutions, tools, and approaches exist for the development and evaluation of safety and automated driving functions. The open source project openPASS was founded to bundle this different development branches and combine forces to reduce waste of resources. Furthermore, openPass is intended to support reliability and transparency of results obtained by simulation. The goal of the Eclipse openPASS working group is to offer a common development platform. The framework shall hold a broad availability of different core modules, which can be used commonly. [1]

The openPASS framework implements the basic structures for developing a stochastic traffic flow simulation. The program sequence is defined and the creation of the scenery and vehicles are basically implemented. In addition, component templates are available for the development of specified agents. Unfortunately, the import of the OpenDRIVE² format is incomplete and the framework as a whole is very rudimental.

2.2 Core modules of the framework

The part of the openPASS framework used by the TUD currently consists of a configuration file set, an output file, and the program code. The configuration files define the program sequence, the road network, and the agent configuration. The agent is the unit consisting of driver and vehicle. After a successful program run, the outcome of the simulation is saved in the output file. This output file logs the observed vehicle state variables related to each time stamp, such as coordinates, velocity, acceleration, and indicator state. These data can be visualized with subsequent post-processing tools. Following this structural overview of openPASS, a more detailed description follows. The core modules of the framework are:

World module

The world module includes all representations of physical objects in the real traffic, like the *scenery*, the *stationary objects*, and the *agents*. The *scenery* describes the road network, the different roads and lanes as well as the connections between them. Also, the scenery holds the coordination information of the road network. *Stationary objects* are visual obstacles, which are immovable. An *agent* represents a unit consisting of vehicle and driver.

² OpenDRIVE is an open file format for the logical description of road networks [2]

Spawn point module

The spawn point module defines the agent type and spawn time of an agent. The *agent* spawn point, the initial velocity, the acceleration, and the yaw angle are calculated and stochastically varied by the spawn point module.

Stochastics module

The stochastics module provides the following mathematical distribution functions: uniform distribution, normal distribution, exponential distribution, gamma distribution and the log normal distribution.

Collision detection module

The collision module monitors the simulation for accidents. At each time step, the bounding frames of the agents are checked for overlapping. If agents collide, the involved identify numbers are transferred to their dynamic component, which processes the accident.

Observer module

The observation module logs all chosen simulation parameters and writes this data into an output file. This output file contains all important vehicle parameters like coordinates, velocity, acceleration and yaw angle, related to each time step. In addition, driver parameters can be logged, such as gaze states, situations patterns, or parameters of the decision making process. Figure 1 visualizes the core modules.

FIGURE 1: VISUALIZATION OF THE FRAMEWORK CORE MODULES

2.3 Basic components of an agent

In the following paragraph, the structure of the agent will be explained. The agent is a functional unit and consists of different components, which are interdependent. The components are interconnected via channels, so that components can communicate. The blueprint of the agent is defined in the system configuration file. The system configuration file prescribes, how the different components interact. Each agent type requires its own description of the system configuration.

To ensure a better overview and functionality, the components are divided into different topics with special authorizations. These topics of an agent are called **sensor**, **algorithm**, **action**, and **dynamics**. In

order to create a component, the framework provides templates for each topic. Figure 2 shows the structure of an agent.

FIGURE 2: STRUCTURE OF AN AGENT

The *sensor* component has access to the world data, like other agents and the scenery. The access to the coordinates and the inertial data of the surrounding agents, as well as the information of the scenery, enable the modeling of vehicle sensors. In addition, it is possible to model human sensors according to the same approach. The Figure 2 contains the "human perception" as an example of such a human sensor.

Algorithm components have only access to their own agent information and transferred information of other components like *sensors*. These available information is processed and submitted to *action* and *dynamic* components. The *algorithm* component represents control units of vehicles or algorithms of safety systems. Furthermore, the human evaluation and decision making process could be represented by an *algorithm* component.

The *action* and *dynamics* components realize the vehicle reactions. All changes of vehicle driving states are executed by *action* components. This includes vehicle signals, such as indicators, flashers, or horns. The *dynamic* component implements the local and temporal changes of the state variables of the vehicle, such as coordinates, velocity, acceleration, and yaw angle.

2.4 Framework adjustments

Currently, the stage of development of the openPASS framework is at a low level. Therefore, a lot of adjustments are necessary to adapt the framework to the desired result.

The road network

One of the biggest changes that has to be made during the import and instantiation of the scenery. The old framework status does not allow the import of road networks. Road networks are connections of different roads via connection elements, such as intersections, driveways, or exits. However, one of the developed traffic simulations is going to be an urban scenario, including intersections. Therefore, the framework had to be adapted to import intersections.

Firstly, the *parser* was adapted to identify intersections and import them correctly into the framework. The *parser* reads the openDRIVE format to import the XML³ structure of the scenery configuration file. The new intersection information is assigned to the object type “intersection”. Furthermore, the existing road network structure was modified, because the successor and predecessor of a road became ambiguous. The assignment of the road-links (information about the connection of different roads) could not be clearly assigned. One road could have up to three successor roads within a intersection. This problem is shown by Figure 3. The new structure considers the road linking concept of intersections of the OpenDRIVE format (for more information about the OpenDRIVE format, see [2]). The new intersection information must be stored in new container types to use the information during the simulation. Finally, the access to the newly implemented road network had to be handled via the agent interface. New functions had to be written within the agent interface.

FIGURE 3: ROAD NETWORK OF AN INTERSECTION ACCORDING TO OPENDRIVE FORMAT SPECIFICATION [2]

The spawn point

The new spawn point module enables the access to the road network. For this purpose, the scenery interface is integrated into the spawn point module. The run configuration file is also modified. The new run configuration file makes it possible to select a specific road via the road-id and a position via the path coordinates of the road where the agent should be spawned. [2]

Furthermore, the agents will be spawned stochastically varied on the available lanes at the chosen position. Another adjustment was the adaption of the testing framework. It enables the testing of the implemented functionalities of the framework.

³ XML – Extensible Markup Language is a markup language that defines a set of rules for encoding documents in a format that is both human-readable and machine-readable.

2.5 Framework additions

Deliverable D2.16 also contains the necessary additions to facilitate the later implementation of the driver behavior model. Therefore, some preparations are useful, which will be explained below.

Within the simulation, the driver is simulated by a perception component and a driver behavior model component. The perception component represents the sensory organs. At this early project level, only the visual perception is modeled. The information received from the perception component is transmitted to the driver behavior model. The driver behavior model includes the cognitive structure. A detailed explanation of the cognitive structure follows in the deliverable D4.15. At present, it is sufficient to know that the cognitive structure models the human evaluation and decision making process. Possible output parameters are lateral deviation, velocity, and acceleration requests.

The basic implementation of the driver perception component is part of D2.16. This includes the implementation of the perception signal from the perception component to the driver behavior component, too. Via this perception signal, all important data of the world get into the driver behavior model and are disseminated.

3 The trial design of the evaluation

This section explains the trial design of the evaluation. First the *simulation parameter set* is considered in **Fehler! Verweisquelle konnte nicht gefunden werden..** Following, the underlying methodological approach is explained in 3.2.

For the explanation of the trial design the following declarations are needed [3].

- A **scenario** represents a conflict that is characterized by frequent occurrence on the road and is going to be addressed by a safety system (e.g. "rear end collision"). It describes the totality of all possible individual cases that can be assigned to this scenario (see situation and support point).
- A **situation** represents a single instance of a scenario that is described by a defined set of parameters. This can be a real case from an accident database, but also a generic simulation result of a single traffic simulation.
- The **situation room** describes the statistical totality of all possible situations of a scenario. It is not a synonym for scenario. The situation room expresses the full extent of the traffic (e.g., collision speeds, collision frequencies, severities of injuries and amounts of property damage).
- The **variation room** describes the situation room of a stochastic simulation on a parametric level.

3.1 The Simulation parameter set

Before a simulation starts, all simulation parameters must be selected. This selection of all parameters is called *simulation parameter set*. A *simulation parameter set* must be defined to ensure that a sample of the *variation room* of the chosen examination scenario is simulated. There are four different parameter types: *fixed*, *variable*, *between* and *result parameter*. Figure 4 shows an exemplary *simulation parameter set*.

FIGURE 4: AN EXEMPLARY SIMULATION PARAMETER SET, WHICH VARY OVER THE BETWEEN PARAMETER "TRAFFIC FLOW"

The *fixed parameters* describe the "hard facts" of the scenario and the simulation runs. They are invariable selected to reduce the simulated *variation room* and the runs of simulation.

Fixed parameters are:

- Common simulation parameters:
 - number of simulations per simulation run (one simulation run consist of a number of simulations)
 - sampling rate of the simulation
- The vehicles with:
 - vehicle width
 - vehicle length
- The road with:
 - road width
 - number of lanes in the direction of travel
 - number of lanes against the direction of travel and their widths
 - character of the traffic junctions

Variable parameters are chosen by stochastic distributions. By the variation of these parameters, possible situations of the *variation room* are displayed. These parameters vary for each simulation within a simulation run.

Variable parameters are:

- The driver with:
 - initial speed
 - reaction time
 - type of reaction
 - deceleration request
- The accident opponent (vehicle/ pedestrian/ cyclist) with:
 - initial speed
 - type of reaction:
 - acceleration
 - no reaction
 - steady movement with constant speed
 - deceleration
 - decelerate up to stop, even before the collision point
 - decelerate up to reversing

The *between parameters* are constant for each simulation of one simulation run, but change between different simulation runs. They are used to examine the influence of a single parameter between different simulation runs.

Between parameters are:

- traffic flow
- visual range
- kind of visible obstructions

Based on the *result parameters*, the safety function is evaluated. For this purpose, the results of the simulations without safety function are compared with the simulations with safety function.

Result parameters are:

- number of accidents
- deceleration of the vehicle resulting from the deceleration request of the driver and/or a deceleration request of an assistance system
- vehicle trajectory resulting from the reaction of the driver
- vehicle speed resulting from initial speed and deceleration of the vehicle
- reaction distance resulting from vehicle speed over time
- collision speed resulting from the initial speed and deceleration of the vehicle
- collision position resulting from the trajectories and speeds of vehicle and accident opponent

3.2 Methodological approach

The aim of the project is the evaluation of safety systems. Therefore, the change of accident events by the use of the safety system to be evaluated is examined. Firstly, a specific examination *scenario* must be chosen. An exemplary *scenario* could be the crossing conflict situation between a car and a pedestrian according to the scenario catalogue of deliverable D1.14.

After this the *simulation parameter set* of the simulation has to be defined (see **Fehler! Verweisquelle konnte nicht gefunden werden.**). It follows the first baseline simulation. The baseline includes a representative part of the *situation room* of the scenario. Therefore, a very high amount of simulations is necessary. The minimal number of simulation runs, which build a representative part of the situation room, will be discussed in deliverable D6.12. It is assumed, that one simulation run consists of at least 10 000 simulations.

Afterwards, the second simulation (the prognosis), with the same *simulation parameter set* plus the safety function to be examined, is conducted. Based on the behavior of the safety function a change occurs within the result parameters. The difference between the two simulation step results are compared. By the comparison of these *result parameters* the effectiveness of safety functions can be evaluated. Further *result parameters* are described in the section above. **Fehler! Verweisquelle konnte nicht gefunden werden.** shows the methodological approach.

FIGURE 5: METHODOLOGICAL EVALUATION APPROACH

4 Human subject / simulator study

[Contribution: LKT / VPSY]

This section is intended to illustrate the upcoming human subject / simulator study, which is cooperatively conducted by LKT and VPSY. First of all, the purpose and the research questions is shown in 4.1. Secondly, the design of the study, based on a static driving simulator, is explained in 4.2. Finally, the details of the implementation in 2019 (see 4.3) are highlighted, followed by a short conclusion and outlook in 4.4.

4.1 Introduction

The development of a plausible traffic flow simulation based on a cognitive driver behavior model cannot be carried out without any connection to real world data, especially without any empirical studies regarding the real driver behavior. Additionally, one has to emphasize, that intersection scenarios are quite different from longitudinal traffic scenarios. Usually, intersection scenarios are mainly executed on the rule-based level⁴, which can be seen in the common patterns of speed reduction and communication with other road users while approaching intersections. In order to conduct the planned intersection maneuver safely, the driver has to apply learned rules and procedures, wherefore the analysis of driver cognition plays an essential part in modeling the driving task at intersections. (cf. [4] p.61)

Thereby, driving simulators represent a major tool for investigations on driver behavior, due to their possibility to control the experience of the participants and to expose them to repeatable scenarios (cf. [5] p.1-2).

In this context, the simulator study is needed to address two major issues regarding the cognitive driver behavior model:

- a) The model parameterization, mainly in terms of eye movement behavior
- b) The validation of the model

The model parameterization is the link to the real driver behavior and can be explained by describing the following research questions:

1. In which kind of segments can the intersection crossing be divided?

This research question is based on the fact, that the driving task at intersections exists of multiple sub-quests, which have to be executed in a particular timeframe and space (cf. [4] p.84). For illustration purposes, an example from Plavšić shall be given (see Figure 6, cf. [4] p.85-90):

⁴ The application of rule-based behaviour means that the driver falls back on a repertoire of stored behaviour patterns (rules) from which he retrieves the most effective variant according to his subjective experience (cf. [9]. P.18).

FIGURE 6: SAMPLE TASK ANALYSIS FOR CROSSING OF AN INTERSECTION (C.F. [4] P.85)

According to the example of Plavšić, the driver recognizes and analyses the intersection during the approach phase. In the deceleration phase, the car is slowed down in order to stop at the intersection, respectively to entry the intersection. In the first crossing phase, an appropriate time gap in the crossing traffic has to be chosen. Subsequently, the driver can evaluate his decision in the crossing two phase and can observe potential vulnerable road users (VRU) on the other side of the street. Finally, the intersection area is left in the exit phase by accelerating to full speed. Thereby, it should be mentioned, that the five subtasks can also be split in several detailed tasks, which have to be identified as well.

2. Based on the identified intersection segments: How can the average car driver behavior be parameterized?

Since it is not possible to investigate and analyze the full range of driver behavior aspects in one simulator study, the study is intended to focus on the driver's eye movement behavior during normal driving. In this case, the eye movement behavior shall be linked to the identified intersection segments in research question 1 in order to parameterize the openPASS model. Hereby, not only the detailed driver behavior for specific situations shall be measured, but also potential eye movement (search-) patterns shall be determined.

While the model parameterization is needed to develop the cognitive driver behavior model, the model validation comes into play relatively at the end. The results of the simulator study should be used to test the developed model for plausible results. Therefore, the research question for the second issue to be addressed is:

3. Does the cognitive driver behavior model map the real driver behavior to a reasonable extent?

At this point, it is to mention, that research question 3 can never be fully answered due to a broad range of limitations in the used measurement instruments, due to the small coverage of real world situations and due to the limited sample itself.

4.2 Study design

The simulator study is executed by VPSY. VPSY covers mainly six research areas, whereby one research topic is focusing on the perception, cognition, and attention during driving. VPSY has its own driving simulator, which will be used for the simulator study and will be introduced later on.

Sample characteristics

The sample is planned to be a cross section of the car drivers in Germany for a better study-generalizability. Due to that, the features of the German average car driver have to be identified and analyzed in the first place. Exemplarily, Figure 7 shows that 2017 the proportion of male and female car drivers / passengers was almost balanced in Germany.

Anytime car availability as driver or passenger (including car sharing)
(n = 316.361)

FIGURE 7: ANYTIME CAR AVAILABILITY AS DRIVER OR PASSENGER IN TERMS OF SEX IN GERMANY 2017 [6]

Moreover, Figure 8 highlights the age distribution of car drivers / passengers in Germany 2017 and emphasizes, that the age group of 50 to 59 years old drivers / passengers is the largest one (20%), whereas only four percent of all drivers / passengers are 80 years or older. Due to simulator sickness⁵, the targeted age distribution will not be able to be complied with exactly. Therefore, the four percent share of 80 years and older drivers / passengers will not be met, for example.

⁵ Simulator sickness is a phenomenon, which is “caused by a mismatch between the visual perception of acceleration or deceleration and vestibular sensation of the same motion” (cf. [5] p.94) and which affects especially test persons from 60 years on (cf. [5] p.95).

FIGURE 8: ANYTIME CAR AVAILABILITY AS DRIVER OR PASSENGER IN TERMS OF AGE IN GERMANY 2017 [6]

Furthermore, Figure 9 explains the average distance travelled with private cars in Germany 2017 and is one factor for assessing the drivers' experience. When the car is used, distances between five up to ten kilometers and ten up to 20 kilometers represent the largest share with ten percent each. However, journeys from 50 kilometers on do not seem to play a major role with a total amount of three percent. Hence, the aim is not only to have a sample, which is equally divided by gender, but also shows an average distribution in age as well as in the drivers' experience.

FIGURE 9: AVERAGE DISTANCE OF CAR JOURNEYS WITH PRIVATE CAR IN GERMANY 2017 [6]

All in all, the sample should contain around 60 persons with complete data sets. A higher number of persons will probably participate as dropouts, due to simulator sickness, and failures in data recording have to be taken into account.

Simulator study setup

As already mentioned, the simulator study will be conducted at VPSY's own static STISIM Drive© driving simulator, which is PC-based and is developed by Systems Technology Incorporation.

FIGURE 10: THE STISIM DRIVING SIMULATOR WITH MERCEDES A-CLASS MOCK-UP AT VPSY

According to Figure 10, the VPSY driving simulator is connected with a Mercedes A-Class mock-up (type 169, build from 2004-2012) for realistic driving simulations in the case of varying visual conditions as well as different vehicle and roadside requirements. The traffic environment is visualized on three LCD displays enabling a 135 degree view. The pedalry consists of acceleration and deceleration pedal, supporting automatic transmission. Two speakers produce the sounds while driving. The eye movement can be tracked by using a head-mounted eye tracking system developed by SensoMotoric Instruments (see Figure 11).

FIGURE 11: SMI HEAD-MOUNTED EYE TRACKING SYSTEM

Driving tasks

The driving tasks can be derived from the variation of within-subject variables. In this context, within-subject means, that a particular road geometry / environment variable value will be varied for one single individual of the sample, e.g. the intersection-geometry (c.f. [7] p.96). This means, that every driver should pass intersections with different geometry. Currently, the following within-subject variables shall be variegated and examined (see Table 1).

TABLE 1: DRAFT OF WITHIN-VARIABLES TO BE VARIEGATED

Nr.	Variable:	Value 1:	Value 2:	Value 3:
1	Traffic density / encounters with other traffic	No traffic	Traffic without encounters	Traffic with encounters
2	Intersection geometry	T- intersection	4 way intersection	-----
3	Right of way regulation	Give right of way	Green traffic light	-----
4	Driving maneuver	Turn left	Turn right	Straight ahead

Combining all within-subject variables would result in 36 different traffic scenarios. However, it is to emphasize, that not all 36 possible scenarios are reasonable to consider as for instance there is no possibility to go straight ahead at T- intersections. Besides, the given timeframe of approximately 45 to 60 minutes simulator ride per test person has to be considered. That is why there will be an initial selection process taking place in order to select only significant scenarios for the simulator study. For instance, in order to limit the number of scenarios due to the limited time frame per test person, the variation of traffic is limited in scenarios having the green traffic light. As the driver has the right of way, other cars will have to wait. However, in scenarios where the driver has to give priority, the behavior of the other cars is highly variable and depending on them, the driver would have to wait.

Apart from that, every test person has to drive a given period of time on normal roads without intersections in order to acclimate and to get used to the simulator in the beginning of the simulator ride. Moreover, there will be a minimum distance between each intersection of at least 400 meters.

Finally, it is intended to divide the test persons into two groups corresponding to the between-subject-design, which examines the differences between individuals (c.f. [7] p.96):

- Group 1: Normal drivers
- Group 2: Distracted drivers

The exact division of the subjects between the groups and the characteristics of the test persons related to the normal and distracted conditions have to be defined later on.

Parameters to be measured

As already mentioned, the study's focus is on the driver's eye movement behavior, respectively on eye movement patterns during normal driving, which shall be linked to previously identified intersection segments.

FIGURE 12: SAMPLE DIVISION OF VIEWING AREAS AT A T- INTERSECTION INCLUDING SEARCH PATTERNS AND ORDER OF FIXATIONS FOR NORMAL AND STRESSED DRIVERS

Figure 12 illustrates a sample division of viewing areas for a driver turning to left at a T- intersection. The purpose of the identified viewing areas is to enable a relatively simple analysis of the driver's eye movement behavior during the simulator ride. This includes the analysis of the recognized objects, the corresponding object fixation time, as well as the areas of the driving environment. Additionally, Figure 12 shows exemplary search patterns and order of fixations for normal and stressed drivers, which shall also be identified by means of the simulator study. Besides the pure eye movement data, it is also planned to record a range of different surrogate safety measures describing the criticality of the corresponding traffic scenarios, e.g. (c.f. [8] p.155):

- **TTC (time-to-collision):**
The TTC describes the time that remains until a collision between two road users would have taken place, if the course of collision and the difference in speed are maintained.
- **ETTC (enhanced-time-to-collision):**
The ETTC considers (complementary to the TTC) the case of accelerating, respectively decelerating, road users and is therefore not defined for the case of constant speed.
- **THW (time headway):**
The time headway is dependent on the parameter "H", which is gauged by taking the time that passes between two road users approaching the same site.
- **PET (post encroachment time):**
The PET describes the moment that a road user exits the field of the potential collision and the other road user arrives in this specific field. The PET is highly relevant for right-angle-collisions, which can be found at intersections.

In order to evaluate the surrogate safety measures, it is also necessary to record almost all parameters of the involved road users, like speed, acceleration, locations (X/Y coordinates), and reaction times. Furthermore, it is planned to conduct a survey before and after the simulator drive, which focuses on subjective driver parameters, especially on the impression of the ride.

All in all, the detailed parameters to be measured are dependent on the capabilities of the driving simulator, which again are dependent on the chosen traffic scenarios. Therefore, they will be determined in the course of further elaboration.

Limitations

Any simulator study has its limitations, wherefore also this simulator study will be restricted by a couple of technical and psychological constraints. The four most important in this context are:

- The limited 135° field of view due to the three LCD-displays, which leads to a driver's shoulder glance out of the projection field,
- the missing movement of the car mock-up, whereby the drivers have to pay more attention to the heading angle (c.f. [5] p.90) and have more difficulties in the speed assessment,
- the steering angle respectively the reaction of the steering wheel, which leads to an enlarged steering radius,
- The phenomenon of simulator sickness, which affects mostly test persons from 60 years of age onwards.

Besides the fact, that the final study design will be optimized to minimize the impact of the mentioned constraints, it will also be tried to fix the errors in the results afterwards.

4.3 Implementation

The study design and implementation is conducted by VPSY, which executes the study itself and analyzes the gained datasets. Thereby, the whole process can be divided into the following work packages (see Table 2):

TABLE 2: WORK PACKAGES AND TIMETABLE OF THE SIMULATOR STUDY

Nr.	Work package:	Responsible:	Start [MM/YYYY]	End [MM/YYYY]
1	Study design	LKT + VPSY	11/2017	03/2019
2	Acquisition of test persons	VPSY	02/2019	03/2019
3	Execution of the simulator runs	VPSY	03/2019	06/2019
4	Data analysis (especially of the eye-movement-behavior)	VPSY	06/2019	08/2019
5	Data interpretation	LKT	08/2019	10/2019

It is to emphasize, that during the whole simulator study – from the design to the interpretation – a weekly four fix meeting is scheduled in order to guarantee an intensive exchange between LKT and VPSY.

4.4 Conclusion and outlook

Conclusion

The development of a plausible traffic flow simulation with an underlying cognitive driver behavior model requires valid driver parameters and a set of validation parameters for the examined traffic situations. Therefore, a simulator study with focus on the driver's eye movement behavior during normal driving at intersections will be conducted. The sample is aimed to be a cross section of the car drivers in Germany and has to perform different intersection driving tasks at a static PC-based STISIM Drive driving simulator, which is built around a Mercedes A-class mock-up. The first simulator runs are scheduled for March 2019 and the data analysis is planned to be completed by August 2019.

Outlook

Depending on the time, the general study progress as well as the total cost, a study extension by investigation of the drivers' behavior in critical traffic situations at intersections will be considered. This extension could include the pure analysis of eye movement patterns in critical situations and could be conducted to a lesser extent by scheduling of a second simulator run period in the end of 2019.

5 Outlook

After the adaptations of the openPASS framework in the deliverable D2.16, the development of the driver behavior model has to be completed. For this purpose, the obtained information of the simulator study have to be integrated into the driver behavior model. Also, the adjustments of the framework have to be continued in task 4.15 and task 5.13. These tasks include the development of additional components and the construction of the stochastic traffic simulation. At the same time, it is necessary to work on the post-processing tool, to evaluate the simulation output.

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