Designing cooperative interaction of automated vehicles with other road users in mixed traffic environments

interACT D.2.3. Sensors and algorithms incorporating the developed models to be integrated into the demonstrator

Work package	WP2: Psychological Models on Human Interaction and Intention Recognition Algorithms
Task(s)	Task 2.3: Detecting interaction features and intention recognition development
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Dissemination level	Confidential (CO)
Status	Final
Due date	07/06/2017
Document date	07/06/2017
Version number	1.0
	This work is part of the interACT project. interACT has received funding from the European Union's Horizon 2020 research and innovation programme under grant agreement no 723395. Content reflects only the authors' view. The Innovation and Networks Executive Agency (INEA) is not responsible for any use that may be made of the information it contains.

This is a draft version of deliverable D2.3.
which has not been approved by the EC, yet.

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Executive Summary

The planning and control of implicit and explicit interaction of automated vehicle (AV) in mixed traffic come along with new requirements for the intention recognition of other traffic participants (TP) and the validation and detection of new features (such as gestures of pedestrians) in the signal processing chain. In the interACT project a new control unit, the Cooperation and Communication Planning Unit (CCPU), is developed in WP3. This deliverable of WP 2 describes methods and approaches for the intention recognition of other TPs, which will be later integrated into the experimental vehicle provided by CRF as a basis for the CCPU. Later in the project, the overall system will be validated with this vehicle.

In detail, this deliverable documents the project work on the following frameworks and algorithms to predict the intention of motorized and non-motorized TPs:

- A general mathematical framework for the **prediction of the location of TPs** using Markov chains was developed, which models the behavior of any moving object. In this work, it is applied to vehicles and pedestrians and is used to evaluate the risk of a situation based on the calculated collision probabilities. This prediction is combined with an anytime A* trajectory planner and can be used to plan trajectories, which do not exceed a certain risk and with risk probability set to zero, it can be used to plan safe trajectories which are guaranteed to be collision free. The effectiveness of the combined prediction and planner is shown for several simulated scenarios. The general framework is useful for different applications and suitable for short-term planning as well as for general risk assessment of traffic situation.
- This general mathematical framework using Markov chains is used to implement a **pedestrian long-term intention prediction** based on an intrinsic motion model of the pedestrian, influences of a semantic map as well as the collision and behaviour models with other TPs. The devolved approach is shown in an example scenario. Furthermore, using the state-of-the-art deep learning techniques, the **head orientation of pedestrians** were accurately classified into predefined directions from the camera images of the AV. This approach allows merging the pedestrian (head) detection in the processing chain with the classification and makes its real-time implementation possible. Besides, the **detection of hand waving gestures** is also performed by means of deep learning approaches. For this, different methods were developed to deal with high-resolution radar measurements and video images, respectively. The evaluation of the pedestrian intention recognition algorithms using real world data shows good performance. Moreover, an approach to **determine the relative position of mobile devices** of other TPs is presented. This approach can provide very accurate position

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estimations of pedestrians and helps to improve the whole signal processing chain by increasing the predicted position accuracy.

- Thirdly, we present a description of the two modules that are responsible for the motorized TP's intention and behaviour identification, namely **the motorised TPs' intention feature recognition and the TPs' behaviour prediction**. The first aims to identify the future intentions of the motorized TPs, as depicted from the AV's perception and the second to anticipate their respective trajectories, using information on the kinematics of the motorized TP.

The outcome of all described modules will be fed in the CCPU, to enable it to identify all AV-to-other TP interactions, match them to traffic scenarios and plan interaction strategies thereafter.

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