A Flexible Architecture for Driver Assistance Systems*

Uwe Handmann, Iris Leefken und Christos Tzomakas

Institut für Neuroinformatik, Ruhr Universität Bochum, 44780 Bochum

Introduction. The problems encountered in building a driver assistance system are numerous. The collection of information about real environment by sensors is erroneous and incomplete. When the sensors are mounted on a moving observer it is difficult to find out whether a detected motion was caused by ego-motion or by an independent object moving. The collected data can be analyzed by several algorithms with different features designed for different tasks. To gain the demanded information their results have to be integrated and interpreted. In order to achieve an increase in reliability of information a stabilization over time and knowledge about important features have to be applied. Different solutions for driver assistance systems have been published. An approach proposed by Rossi et al. [8] showed an application for a security system. An application being tested on highways has been presented by Bertozzi and Broggi [1]. Dickmanns et al. presented a driving assistance system based on a 4D-approach [2]. Those systems were mainly designed for highway scenarios, while the architecture presented by Franke and Görzig [3] has been tested in urban environment.

Architecture. In contrast, the content of this paper concentrates on a flexible, modular architecture of a driver assistance system working on evaluation and integration of the actual information gained from different sensors. The modules of the architecture are represented by the object-related analysis, the scene interpretation and the behavior planning (fig. 1). The accumulated knowledge is

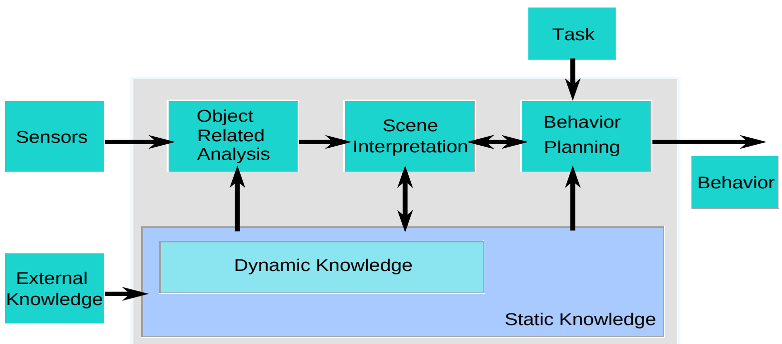

Fig. 1. Architecture for a driver assistance system

* Extended abstract of the paper *Eine flexible Architektur für Fahrerassistenzsysteme* [6] presented at the DAGM'99/KI'99 symposium.

organized in the knowledge base. The presented architecture is able to handle different tasks. New requirements to the system can be integrated easily. The proposed architecture is intended to produce different kinds of behavior according to given tasks. Information about the actual state of the environment is perceived by the system's sensors. The data collected by each sensor have to be processed and interpreted to gain the desired information for the actual task.

Object-related Analysis. The object-related analysis can be subdivided into a sensor information processing and a representational part. In the sensor information processing part the collected sensor data are preprocessed (e.g. segmentation, classification of regions of interest (ROI) or lane detection) and interpreted according to their capabilities. The processing can be performed for each sensor as well as information from different sensors can be fused [7]. Objects are extracted by segmentation, classification and tracking (fig. 2). The results of the

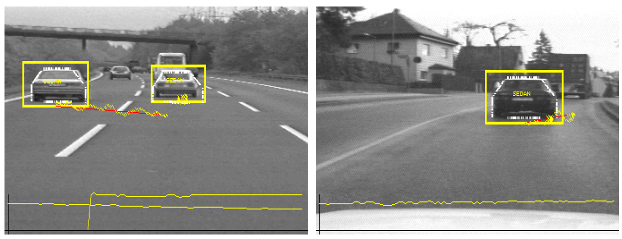

Fig. 2. Vision-based object detection, object classification and object tracking

sensor information processing stage are stabilized in movement-sensitive representations by introducing the time dimension. In this sense, a ROI is accepted as a valid hypothesis only if it has a consistent history. This is implemented by spatio-temporal accumulation using different representations with predefined sensitivities. The sensitivities are functions of the objects' supposed relative velocity and of the distance to the observer (fig. 3). In order to apply a time

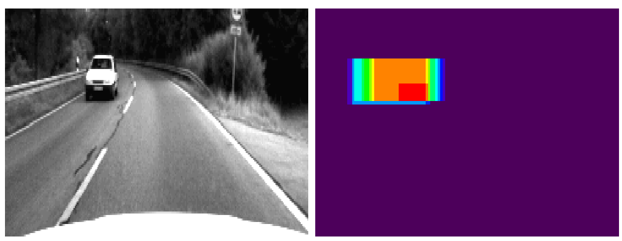

Fig. 3. Image and representation: prediction and object detection of oncoming vehicles

stabilization to these regions and to decide whether they are valid or not, a prediction of their position in the knowledge integration part is realized. A competition between the different representations and a winner-takes-all mechanism ensures reliable object detection. An implementation of an object-related analysis on vision data has been presented in [4]. The results are passed to the scene interpretation.

Scene Interpretation. The scene interpretation interprets and integrates the different sensor results to extract consistent, behavior-based information. The scene interpretation is subdivided into a behavior-based representational and a scene analysis part. Objects and lane information are transformed to world coordinates with respect to the moving observer. The positions of the detected objects are determined in a bird's eye view of the driving plane. This dynamically organized representation is shown in fig. 4. The transformation rules follow the given position of the CCD camera in the car and the position of the car on the lane. The physical laws are given by the transformation equations for the camera and physical considerations of the movement and position of potential objects. The transformation also depends on constant data (e.g. length of a vehicle according to its classification). The scene analysis sustains the driver assistance

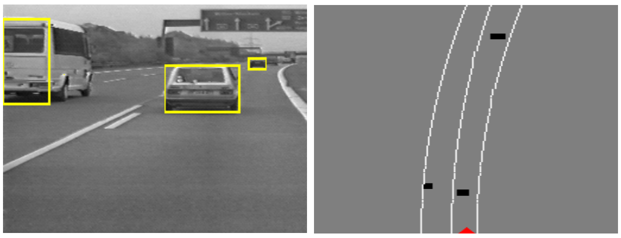

Fig. 4. Image with objects and bird's eye view

by evaluating the actual traffic condition as well as the scenery. According to the actual traffic condition and the planned behavior a risk-factor for actions is estimated. The determination of the traffic condition is performed by evaluating the information from scene interpretation. This is done by counting the objects, evaluating their relative speed and the movement according to their class. The scenario can be determined using GPS and street maps for investigating the kind of street, e.g. highway, country road or urban traffic. According to these scenarios different objectives have to be taken into consideration. The determined traffic condition as well as the classified scenario are proposed to the behavior planning.

Behavior Planning. The behavior planning depends on the given task and on the scene interpretation. Different solutions for the planning task are possible. A rule-based fuzzy-logic approach is described in [10]. An expert system is shown in [9]. In the present system an intelligent cruise control system was integrated.

Behavior planning for the observer results in advices to the driver which are not only based on the intention to follow the leader but on regards concerning the safety of the own vehicle. This means that the object cannot be followed or might be lost in case of other objects or obstacles endangering the observer. The signal behavior for the main tasks is determined by a flow diagram shown in [5].

Knowledge Base. The knowledge needed for the evaluation of the data and for information management is given by the efforts of the task of driver assistance, by physical laws and traffic rules. An improvement of the results can be achieved by the information of the knowledge base. In the knowledge base static and dynamic knowledge is represented. Static knowledge is known in advance independently of the scenery of movement (e.g. physical laws, traffic rules). Dynamic knowledge (e.g. actual traffic situation, scenery) is knowledge changing with the actual information or with the task to be performed (e.g. objects in front of the car). Dynamic knowledge can also be influenced by external knowledge like GPS-information.

Conclusion. The proposed architecture has been tested on a simulation surface.

References

1. M. Bertozzi and A. Broggi. GOLD: a Parallel Real-Time Stereo Vision System for Generic Obstacle and Lane Detection. In IEEE, editor, *IEEE Transactions on Image Processing*, volume 4(2), pages 114–136, 1997.
2. E.D. Dickmanns et al. Vehicles capable of dynamic vision. In *15th International Joint Conference on Artificial Intelligence (IJCAI)*, pages 1–16, Nagoya, Japan, 1997.
3. S. Goerzig and U. Franke. ANTS - Intelligent Vision in Urban Traffic. In *IV'98, IEEE International Conference on Intelligent Vehicles 1998*, pages 545–549, Stuttgart, Germany, 1998.
4. U. Handmann, T. Kalinke, C. Tzomakas, M. Werner, and W. von Seelen. An Image Processing System for Driver Assistance. In *IV'98, IEEE International Conference on Intelligent Vehicles 1998*, pages 481 – 486, Stuttgart, Germany, 1998.
5. U. Handmann, I. Leefken, and C. Tzomakas. A Flexible Architecture for Intelligent Cruise Control. In *ITSC'99, IEEE Conference on Intelligent Transportation Systems 1999*, Tokyo, Japan, 1999.
6. U. Handmann, I. Leefken, and C. Tzomakas. Eine flexible Architektur für Fahrerassistenzsysteme. In *Mustererkennung 1999*, Heidelberg, 1999. Springer-Verlag. DAGM'99.
7. U. Handmann, G. Lorenz, T. Schnitger, and W. von Seelen. Fusion of Different Sensors and Algorithms for Segmentation. In *IV'98, IEEE International Conference on Intelligent Vehicles 1998*, pages 499 – 504, Stuttgart, Germany, 1998.
8. M. Rossi, M. Aste, R. Cattoni, and B. Caprile. The IRST Driver's Assistance System. Technical Report 9611-01, Instituto per la Ricerca Scientificia e Technologica, Povo, Trento, Italy, 1996.
9. R. Sukthankar. *Situation Awareness for Tactical Driving*. Phd thesis, Carnegie Mellon University, Pittsburgh, PA, United States of America, 1997.
10. Qiang Zhuang, Jens Gayko, and Martin Kreutz. Optimization of a Fuzzy Controller for a Driver Assistant System. In *Proceedings of the Fuzzy-Neuro Systems 98*, pages 376 – 382, München, Germany, 1998.