EMS-Vision: Combining on- and off-road driving

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ABSTRACT

In the past, work at the "Universität der Bundeswehr München" (UBM) has been focused on autonomous road vehicles. During the last four years the Expectation-based Multi-focal Saccadic Vision (`EMS-Vision`) system has been developed and implemented. `EMS-Vision` is the 3rd generation dynamic vision system following the 4-D approach. The explicit representation of the own capabilities combined with a complex control and information flow allows the implementation of decision units for goal oriented activation of locomotion and perception. Due to this general approach and in contrast to former UBM systems that were specially designed and optimized for certain limited scenarios and domains, e.g. road following on Autobahnen, the `EMS-Vision` system can handle complex driving missions spanning multiple domains. It has been realized on a decentralized parallel hardware structure, exclusively built of commercial off-the-shelf components, in both UBM test vehicles VaMoRs and VaMP. Results from an autonomously performed mission on the UBM campus are discussed.

Keywords: active vision system, control of perception and action, autonomous vehicles, dynamic machine vision, on- and off-road driving

1. INTRODUCTION

Since nearly two decades autonomous systems are a topic of intense research. From the mid 80ies on, several national and international programs have been initiated all around the world, like AVCS in Asia, IVHS[1] and PATH in the United States or DRIVE and PROMETHEUS in Europe. The main goals in these civilian programs have been to increase safety and efficiency in normal traffic. Thus, many research groups concentrated on the development of functionalities for autonomous road vehicles being able to interact with other vehicles in a cooperative manner. Countless approaches have been developed and often abandoned over the years. Impressive results have been demonstrated by the most successful groups, like from Carnegie Mellon University (CMU) C. Thorpe et al.,[2] from University of Parma A. Broggi et al.,[3] from the "Fraunhofer-Institut für Informations- und Datenverarbeitung" (IITB)[4] in Karlsruhe, from Daimler-Benz Forschung U. Franke et al.[5] and from UBM.[6]
For the next step on the way to an autonomous road vehicle, the navigation on road networks, more challenging problems like intersection recognition and complex driving maneuvers had to be solved. Only few groups have been able to present results from real driving tests like CMU,[7] IITB[8] und UBM.[9]

In military research programs, like PRIMUS[10] in Germany or UGV / DEMO I-III[11] in the US, the main focus is on the development of autonomous vehicles for unstructured, rough terrain. While GPS-based waypoint navigation is a well established technique for global path following, a variety of sensors are used for obstacle detection and local path following. In PRIMUS, the Dornier company relies on a laser-based range camera (LADAR) for obstacle detection. The DEMO III project applied both vision-based sensors provided by JPL[12] and LADAR provided by NIST.[13]

However impressive the results achieved in these distinct domains are, there is no system (at least to the authors' knowledge), where funcionalities for handling all domains were successfully integrated to perform a joint mission without interference from a human operator. The transitions between the domains, where new perception processes have to be initialized, seem to be the most challenging problem. Within the PRIMUS project, Dornier presented autonomous capabilities for both vision-based road following[14] and cross-country navigation[15] during one demonstration, but road recognition had to be initialized by a human operator in the remote control station.