

Summary of doctoral dissertation entitled: Statistical approach to verification and validation of control systems in autonomous vehicles

Author: Paweł Kowalczyk

Abstract: In order for an autonomous car to be able to make decisions adequate to the environment and the situation on the road in which it is located, the raw data collected by the sensors must be properly interpreted and transformed so as to be "understandable" for the control algorithms. This type of analysis is largely carried out by many specialized neural networks that constitute the core of the perception modules that form the basis of an advanced driver assistance system (ADAS). In the process of developing perception modules, it is crucial to test how precise and trustworthy interpretation of sensor data is. To do this there is a need of metrics that evaluate and compare the results of the perception modules with the prepared labels (reference data) for the test scenes on which the module is tested. Evaluation should be multi-stage and take into account various aspects of data geometry and safety on the road. Moreover, the quality analysis should be carried out on an experimental setup composed of many test scenarios with different road context and weather conditions. Characterizing such complex datasets and structuring the process of qualitative analysis based on them is a huge challenge and necessary in the development of the perception of autonomous cars. The author of the work creates a metric comparing rectangular recognition regions that are used to describe objects on the road. These include cars, pedestrians, signs and traffic lights recorded on film frames from the front camera or other sensors. These metrics take into account the geometry of the data and the context of their creation to put emphasis on the evaluation of relevant aspects of the perception module operation. Using the designed metrics, the author conducts an extensive comparative experiment analyzing the impact of video data degradation on the quality of the perception module, taking into account various conditions in the test scene and the original shape of the quality distribution. For this purpose, author uses the concept of Wasserstein metric, using it in the clustering algorithm and to analyze change in quality distribution. The last part of the thesis deals with the issue of characterization of sets of test scenarios understood as sets of trajectories of objects within the range of the moving center of the reference system, which is a car equipped with perception modules. The author proposes a method of clustering of occupancy grids to expand the formal description of large data sets used in the automotive industry for the development of advanced driver assistance systems, which is necessary to correctly evaluate their usability and optimize the process of learning neural networks.