Doctoral thesis – Summary

Development of methodology for creating automated tests of embedded systems test in automotive vehicles, enabling verification of the results using augmented intelligence algorithms

Author: MSc. Eng. Anna Gnacy-Gajdzik

Supervisor: Ph.D. D.Sc. Eng. Piotr Przystałka, Associate Professor

Industry supervisor: Ph.D. Eng. Wojciech Sebzda

Embedded systems in automotive applications are becoming increasingly complex and, above all, they implement functions that affect the safety of road users. Verification of designed embedded systems, in terms of fulfilment of requirements, especially for functional safety, is an essential stage of product development. One of the main problems that arise when automating the testing process are anomalies occurring in test environments, which may influence on the results and lead to the so-called flickering results. This subsequently causes an increase in the cost and duration of the testing due to the necessity of analyzing each negative result.

The dissertation proposes an innovative methodology for creating automated tests of embedded systems that enables the application of augmented intelligence at the stage of verification of the test results correctness. For this purpose, the study proposes two algorithms based on the synergy of artificial intelligence with human intelligence, which allows the fast processing of vast data volumes collected from the test environment and the application of machine learning. However, the human being supervises the entire process and is responsible for results and confirmation that the tested embedded system satisfies all requirements and it is not a potential threat to people's life and health.

The formulation of the methodology required extensive, interdisciplinary research and development efforts. This was due to the need for identifying the phenomena occurring in the test environment, their impact on the mechatronic components of the embedded system, developing augmented intelligence algorithms based on machine learning algorithms. To address challenges of improving the quality of testing process, a modification of the test environment was proposed as part of the presented methodology. It involves applying a vehicle model in the simulation, which allows for reflecting the influence of vehicle mechanics on the tested functions of the embedded system. The paper contains a detailed description of the research test bench, which includes the vehicle simulation model. The third stage of the research confirmed its positive impact on the effectiveness of identifying embedded system defects related to vehicle's motion dynamics. The effectiveness of two proposed augmented intelligence

algorithms was evaluated: one based on recurrent neural networks (with LSTM and GRU layers) and second incorporating anomaly detection algorithms. It was confirmed that both solutions successfully identify anomalies in the test environment that cause flickering results and indicate false negative test results. Verification of the proposed methodology was performed on the datasets recorded during the execution of test cases prepared in accordance with its guidelines, both in the original test environment and in the environment enhanced with the vehicle model.

The results of the dissertation provide an important contribution to the safety and reliability of embedded systems designed in the automotive industry, and in particular to the optimization of the testing process. The application of a vehicle model as a modular and configurable element of the test environment positively affects the quality of embedded systems, enhancing the efficiency and credibility of the testing process. The proposed efficient and scalable methodology for creating automated tests of automotive embedded systems enables efficient verification of test results correctness using augmented intelligence algorithms.