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The use of adaptive filtering, fuzzy logic, and UWB technology to identify and locate objects to validate algorithms in ADAS subsystems

Abstract of the Doctoral Dissertation

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Abstract

One of the basic problems of the Advanced Driver Assistance Systems (ADAS) that are currently emerging is the complexity and time-consuming nature of the algorithm validation process, which is largely influenced by the location and identification of objects in the vicinity of the vehicle. At the same time, the dynamic development of UWB technology and the predisposition of this technology to dimensioning with the simultaneous possible data transmission seem to be potential support in the validation of ADAS algorithms. Taking into account the above observation, the following thesis was proposed, saying that it is possible:

The use of adaptive filtering, fuzzy logic, and UWB technology to identify and locate objects to validate algorithms in ADAS subsystems

In the doctoral dissertation, a proposal for a system was presented, which is to allow the labeling of objects while determining their position, which will speed up the process of validation of new ADAS algorithms. The work consists of five stages leading to the achievement of the goal. The first is to present the current state of knowledge related to both the positioning of objects and the basic concepts related to its implementation. Then, the basics of UWB technology and the principles of its operation were discussed. It was also indicated that it could be used in the context of the mentioned functionalities and technologies, and a SWOT analysis of this solution was carried out. The main element of the work was to propose a scheme for the processing of dimensioning data from a system based on UWB technology. It consists of the stages of acquisition, and the use of adaptive preliminary filtration. The next step is processing with the use of fuzzy logic based on the analyzed Mamdani and Takagi-Sugeno approaches. This leads to an increase in the accuracy of the location of marked objects in the vicinity of the vehicle. Finally, the system, depending on the available data, uses trilateration to indicate the location or the distance and angle at which the object is located in relation to the vehicle axis. The transmission of metadata related to the road infrastructure proposed in the work is a complement needed for the validation of ADAS subsystems. It is an original proposal for labeling objects. An analysis of data transmission, available space, proposed methods, and data structure was performed here, taking into account the necessary data and acceptable time.

The demonstrated ability to identify and locate, with the simultaneous use of adaptive filtering with fuzzy logic, allows the use of the UWB system for the validation of algorithms in ADAS subsystems. The accuracy of the proposed solution in relation to the accuracy of other systems discussed in the literature is better or comparable, with the simultaneous advantage of being able to identify or even operate in conditions unattainable for other systems (e.g. NLOS). The innovative nature of the research is best demonstrated by the current lack of literature that would deal with the subject of positioning systems using UWB technology, especially in the context of outdoor applications, in the field of automotive technology. The presented solution can be used in the rapidly developing branch of automotive technology, thus allowing the minimization of costs related to the development and prototyping of new systems. The conclusions resulting from the conducted research indicate that based on UWB technology, a system can be successfully created that allows for quick identification of objects (infrastructure, vehicles, people), their precise location, and monitoring of their properties.