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Adaptive Operational Design Domain

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Abstract

Developing a safe and reliable autonomous system is a pivotal challenge across all automation endeavors. Within the automotive sector, the Operational Design Domain (ODD) concept, as outlined by SAE J3016 [1], supports safety by specifying the conditions under which the autonomous system is designed to operate.

As the development of the ODD in autonomous systems continues, there is a need to ensure the safety of impaired autonomous systems functionality. The current ODD concept considers only static operational domains, i.e., the system is either inside or outside the ODD. There is no process to handle a gradually affected autonomous system. In addition, there is no technique to handle a gradual reduction of operating conditions for the current operational domain [2].

In response to this challenge, we introduce the concept of the Adaptive Operational Design Domain (AODD) as a solution for increasing the availability and support of the safety of a system, even when a system is impaired, e.g., an affected braking system, by extending the definition of the ODD. The AODD specifies conditions under which the impaired autonomous system is designed to operate.

In an impairment, the system's functionality transitions to a restricted system's functionality. The restricted system's functionality requires an adaptation of the ODD to ensure the continued safe operation and availability of the autonomous system within an adapted domain. This adaptation requires adjusting the ODD to accommodate the restricted system's functionality, which may avoid to fall back to e.g. minimal risk maneuvers [2].

Consider, e.g., a scenario where the braking system [3] becomes partially affected during operation, causing a reduction in braking and leading to an increased braking distance for the vehicle. To ensure continued operability in such circumstances, the ODD has to be adapted, which means a fitting AODD has to be determined. The AODD must quickly assess the scenario and determine appropriate measures under real-time conditions. The autonomous driving function controls the vehicle according to the safety requirements of the ODD or, in the event of impairment, according to the safety requirements of the AODD. This involves adapting the parameters of the ODD to accommodate the changes in the system behavior due to the dysfunction. Once a suitable parameter set is identified, the system can continue to operate safely within the defined AODD. For example, in this specific scenario, two parameters could be changed, the maximum speed of the vehicle can be reduced, or the minimum safety distance to other traffic participants can be increased.

The transition from ODD to AODD may shrink the safe parameter space, which may lead to a reduction in the number of safe logical and, consequently, a reduction in safe concrete scenarios [4, 5], but the AODD ensures that the system can maintain safe operation within its system bounds. In cases where an AODD cannot be determined, the autonomous vehicle system still may have to perform e.g. a minimal risk maneuver.

The introduction of the AODD addresses affected functionality and enables the autonomous system to maintain its operability in the event of an impairment. The advantage of AODD is the maintained operability of the system, which increases the safety, because it can continue driving further without stopping in unknown or potentially dangerous environments, e.g., stop on the emergency lane. Furthermore, AODD enables autonomous systems to make consistent decisions without human intervention by ensuring that the affected system can adapt to changing circumstances.

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