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主　論　文　の　要　旨

論文題目　Modeling, Analysis and Assurance for Non-Functional Requirements regarding Autonomous Driving Systems and Services
（自動運転システム・モビリティサービス向け非機能要求のモデリング・分析・保証手法）

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論　文　内　容　の　要　旨

Non-functional requirements (NFRs) are system requirements other than functional requirements. An NFR refers to a system quality index such as safety, security, usability, performance, and extensibility, and it is an integral part affecting the quality of a system engineering project. However, in the development of Autonomous Driving Systems (ADS) and Advanced Driver Assistance System (ADAS), the focus tends to be placed on functional requirements, and there is little research on NFR assurance. To fill this gap, we propose in this dissertation an NFR assurance methodology for ADS development. The proposed methodology consists of 4 intrinsically related approaches.

Many dependability engineering approaches have been explored in existing studies. Nevertheless, there is no means to compare multiple architectural design strategies, as no method has been proposed to quantitatively evaluate the dependability requirements of system architecture. We propose in Chapter 3 a quantitative evaluation method for dependability assurance to narrow this gap. Although lots of research on the cyber security analysis of ADS has been conducted, there is little research that complies with the newly issued ISO/SAE 21434 international standard for road vehicles' cyber security engineering. In Chapter 4, we present a cyber security analysis approach based on ISO/SAE 21434 standard. As we enter the smart era, a new concept of Safety 2.0 that transcends Safety 1.0 is necessary, especially in ADS development. Existing research has proposed methods to analyze the resilience of individual systems and software (e.g., FTA, STAMP/STPA, FRAM), but no service-level resilience engineering approach has been found to ensure resilience for System-of-Systems (SoS). In addition, traditional modeling languages (UML, SysML) do not have the business layer, so it is difficult to implement service modeling. In

Chapters 4, we have presented an approach for dependability analysis and evaluation, but have not proposed an approach for developing resilience for dependable SoS. To fill this void, Chapter 5 proposes an approach to analyze and design resilience for Mobility-as-a-Service (MaaS) based on the IEC 62853 standard. In addition to safety, cyber security, and resilience, there are other qualities that are required for IT services. As a representative example, innovation has been attracting attention recently. There is a need for a methodology to create disruptive innovation by solving the problems that customers are struggling with via information technology. To address this problem, we propose in Chapter 6 an EA modeling methodology to visualize ADS architecture consistent with business and analyze MaaS as innovation.

In summarize, in this dissertation we have proposed an NFR modeling, analysis, and assurance method for ADS, and carried out 6 case studies and 4 experiments to verify the effectiveness of the method. In addition, limitations of the proposed method are discussed and future directions of this research are clarified.