Knowledge Based Engineering to Support Automotive Electric and Electronic System Design and Automatic Control Software Development

Background
Based on the statistic data from OICA and NHTSA, it has been found that the percentage of vehicles being affected because of failures in the electronics, either software or hardware drops gradually from almost 8% (2003) to less than 2% (2009). However, significant changes have taken place in 2010 and 2012, which makes up more than 10% of the vehicle production in that year (Fig.1).

The level of software integration in vehicles, such as electric cars and aircraft, is rapidly increasing. Due to the increasing complexity of the embedded control software, significant delays can occur in development programs or even errors can be present in the control software of the final product. In the development of the Electric and Electronic system (E/E system), the analysis and specification for the architecture of the logical system, technical system and software itself includes many repetitive (manual) processes. Those repetitive processes are time consuming and are prone to errors.

Methodology
The Design and Engineering Engine (DEE) for automotive conceptual design has been established in this research (Fig.2). The new methods and tools that allow the designer to take electronic components, including control software, into account already in the automotive conceptual design. The DEE is based upon the principles of Knowledge Based Engineering (KBE), which is essentially a combination of Computer Aided Design (CAD) and Artificial Intelligence (AI). Moreover, the Multi-Model Generator (MMG) which is the heart of the DEE has been developed (Fig.2). The MMG is able to model different automobile configurations and configurations' variants and provide models for multidisciplinary analysis, such as mechanics, aerodynamics, dynamics and E/E systems as well. The MMG can establish the relationship from the logical system architecture to the technical system architecture and finally the software components for the E/E systems. It can also model the logical, technical architecture and automatically generate the source code for the software components.

Test case --- The development of Anti-lock Braking System (ABS)
Based on a single intelligent product model, that contains the main design parameters of the vehicle specified by the designer, two models are generated automatically; (1) the simulation model of the physical plant (geometric model) and the associated control system (dynamic model), and (2) the control software (source code). The simulation model is used to test the source code for a range of ABS maneuvers. Results show that the source code of the control software behaves identically to the original simulation model of the control system. The final source code is well-structured and easy to understand due to the fact that there is a direct relation between the vehicle design parameters specified in the original product model and the variables and their values in the source code of the control software. The proposed design methods and tools can in principle be applied to any dynamic system with a high level of software integration, such as e.g. unmanned aerial vehicles.

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Progress and Objectives
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Aerodynamic drag coefficient for a sphere

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