LARGE LANGUAGE MODELS FOR AUTOMOTIVE EMBEDDED ELECTRONICS

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Summary This study investigates the use of Large Language Models (LLMs) to support the design and modeling of automotive embedded electronics. By fine-tuning pre-trained LLMs on automotive-specific datasets consisting of E/E architecture models, requirements, and model behavior, and integrating human-in-the-loop feedback, we explore their potential to assist engineers with system modeling, component selection, architecture optimization, and documentation. An evaluation phase is included to assess the relevance, usability, and potential efficiency gains of the assistant in comparison to traditional workflows.

INTRODUCTION

Automotive embedded electronics are becoming increasingly complex due to the rapid growth of Electric/Electronic (E/E) architectures and the shift toward software-defined vehicles. Traditional engineering workflows demand significant manual effort and deep domain expertise [5]. Recent progress in Large Language Models (LLMs), including GPT and LLaMA, offers opportunities to automate non-creative tasks such as documentation, code generation, and model validation, while supporting engineers with design suggestions [1].

In this context, our work focuses on integrating LLMs within Dassault Systemes' *CATIA Systems Engineering* environment to evaluate their potential to assist in automotive electronics design and model-based engineering, while ensuring alignment with domain-specific constraints.

METHODOLOGY

The methodology is structured around three complementary steps, designed to progressively adapt and evaluate LLMs for automotive engineering tasks:

1. **Domain-specific fine-tuning:** Pre-trained LLMs are adapted to automotive embedded electronics using datasets composed of E/E architecture models, requirements, and model behavior [4]. Multiple model architectures, including GPT-style and open-source LLaMA variants, are considered to identify those best suited for engineering tasks.

2. **Integration and experimentation:** Fine-tuned models are deployed in Dassault Systemes' sandboxed engineering environments [2]. Experiments involve realistic scenarios, such as component recommendation, interface documentation generation, and preliminary architecture synthesis.

3. **Evaluation and contextual learning:** Human-in-the-loop evaluations refine model outputs to align with engineering standards, safety constraints, and usability requirements [3]. A structured evaluation, including user feedback and comparison with existing workflows, is performed to provide objective insight into the benefits and limitations of the system.

EXPECTED RESULTS

The main outcome is an LLM-based assistant, internally referred to as *Leo*, capable of interacting with system models through natural language. Expected capabilities include:

- Automated analysis of system requirements to suggest appropriate components, reducing manual effort and repetitive tasks [2].
- Providing knowledge-based answers on E/E architectures, components, and design rules.
- Supporting consistent system architecture generation and interface documentation.
- Facilitating error detection and offering explanations to assist engineers in understanding design choices [5].
- Generation of quantitative and qualitative evaluation data, such as accuracy, consistency, and user feedback, to assess the relevance and usability of the assistant.

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DISCUSSION

Integrating LLMs into automotive design pipelines could improve workflow efficiency and support knowledge reuse. Including a structured evaluation allows for a more objective discussion of the assistant's performance and highlights areas where LLMs provide measurable benefits while maintaining necessary human oversight. Challenges such as data confidentiality, model interpretability, and compliance with safety-critical standards remain critical [3].

CONCLUSION

This study demonstrates the potential of LLMs as intelligent assistants in automotive embedded electronics. Through targeted fine-tuning, contextual learning, and human-in-the-loop evaluation, LLMs can support engineers in complex design workflows, bridging the gap between natural language reasoning and formal system modeling. By including an evaluation phase, the study provides both practical insights and scientific contributions regarding AI integration in engineering processes.

References

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