Large Language Models in Software Engineering: A Human-in-the-Loop Framework for Quality, Safety, and Adoption

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Abstract:

Large language models (LLMs) are increasingly used to support software engineering tasks such as requirements work, code generation and modification, bug fixing, test creation, documentation, and maintenance. However, LLM-assisted development introduces new quality and safety risks, including non-deterministic behavior, hallucinations, limited auditability, and security and privacy concerns. Consequently, responsible adoption requires human-in-the-loop (HITL) processes in which human experts deliberately guide, verify, and approve model outputs at well-defined control points (e.g., review gates, test gates, and security validation steps).

This Ph.D. project aims to (i) systematically analyze and structure how LLMs are applied across the software development lifecycle and identify high-value as well as high-risk areas, (ii) propose a HITL methodological framework for integrating LLMs into software engineering practice—covering task criticality classification, verification strategies, quality metrics, and auditability mechanisms—and (iii) empirically validate the framework on selected representative tasks using reproducible experimental protocols and realistic artifacts. The evaluation will compare baselines without LLM support and without HITL controls, and it may leverage established benchmarks for real-world issue resolution such as SWE-bench to quantify benefits and trade-offs under controlled yet realistic conditions.

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