
REPORT ASSEGNO DI RICERCA APRILE 2025 - SETTEMBRE 2025

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1 Information Assegno

Titolo: Raccomandazioni affidabili per lo sviluppo di software complessi

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Responsabile Scientifico: Davide di Ruscio

2 Research Activities

During the period from April 2025 - September 2025, I was involved in different research activities that I'm partially summarizing as follows:

- **Energy-Aware Prompt Engineering for Large Language Models: An Empirical Study on Software Engineering Tasks** The growing environmental impact of AI-based software systems, particularly those leveraging large language models (LLMs), necessitates urgent investigation into their substantial resource consumption, which contributes significantly to data center load and carbon emissions. This paper extends our prior work on LLM energy consumption, which focused solely on Llama 3.0 for code completion, by empirically analyzing the influence of Prompt Engineering Techniques (PETs) on the energy footprint of two prominent LLMs: the general-purpose Llama 3.1 and the specialized CodeLlama. Our investigation spans two distinct natural language tasks: code completion and textual summarization of GitHub README.md files. Specifically, we examine the impact of custom prompts on code completion and the effect of input formatting (comparing plain text, Markdown, and HTML representations) on the textual summarization task. Our findings indicate that prompt customization positively influences the energy efficiency of both Llama 3.1 and CodeLlama. However, for the textual summarization task, the specific input format (plain text, Markdown, HTML) appears to have a less pronounced contribution to energy consumption. Notably, CodeLlama consistently exhibited a substantially higher energy footprint compared to Llama 3.1 throughout the majority of our experimental evaluations, highlighting potential differences in resource demands between general-purpose and specialized models. This is the first work systematically linking prompt design to energy consumption in LLM-based software engineering tasks. We are planning to submit this work to ACM Transactions on Software Engineering and Methodology (TOSEM).
This work is a direct extension fo the one entitled "Prompt engineering and its implications on the energy consumption of Large Language Models." Presented at IEEE/ACM 9th International Workshop on Green and Sustainable Software (GREENS). IEEE, 2025.
- **Empirical Study on Code Refactoring by Means of Multi-Agent Systems** In the lifecycle of modern software development, refactoring stands as a foundational and essential practice. It is a systematic process aimed at improving the internal structure and design of existing code without altering its external behavior or functionality. This practice is critical for maintaining code quality, ensuring that a system remains high-performing, maintainable, and secure as it evolves over time. A multi-agent system (MAS) operates as a team of specialized AI agents, each with its own capabilities and local view of the system, working together to solve

a complex problem. The collective behavior of these agents increases the potential for accuracy, adaptability, and scalability, allowing them to outperform single-agent systems. This is achieved through the distribution of a massive cognitive load into manageable, focused tasks, enabling parallelization and improved fault isolation. By leveraging the objective, structured signals from SonarQube's static analysis as a trigger and success metric, the proposed MAS can address many of the core limitations of single-agent, monolithic AI models. This hybrid system, with its specialized agents for analysis, execution, and verification, presents a promising path toward automating complex, goal-oriented refactoring tasks while maintaining correctness and security.

3 Research products

- Muttillio, Vittoriano, et al. "Leveraging synthetic trace generation of modeling operations for intelligent modeling assistants using large language models." *Information and Software Technology* 186 (2025): 107806.
- Di Sipio, Claudio, et al. "On the Need for Reproducibility Guidelines for Open-Source Games: A itch. io Case Study." *2025 IEEE Conference on Games (CoG)*. IEEE, 2025.
- Imran, Muhammad, et al. "Is code coverage of performance tests related to source code features? An empirical study on open-source Java systems." *Empirical Software Engineering* 30.6 (2025): 157.
- Rubei, Riccardo, Amleto Di Salle, and Alessio Bucaioni. "LLM-Based Recommender Systems for Violation Resolutions in Continuous Architectural Conformance." *2025 IEEE 22nd International Conference on Software Architecture Companion (ICSA-C)*. IEEE, 2025.
- Rubei, Riccardo, et al. "Prompt engineering and its implications on the energy consumption of Large Language Models." *2025 IEEE/ACM 9th International Workshop on Green and Sustainable Software (GREENS)*. IEEE, 2025.

4 Participation In National And International Research Projects

From June 2022: PRIN 2021 research project consortium "EMELIOT (Engineered MachinE Learning-intensive IoT systems)." The EMELIOT project aims to study solutions for engineering highly-dependable, ML-intensive IoT systems. EMELIOT foresees systems where different sensors collect data from physical systems, which in turn can get their status changed by actuators. Collected data are filtered, aggregated, and used to manage ML models locally, on the edge, by dedicated IoT gateways, or on remote cloud servers.

TRex-SE The project TRex-SE (Trustworthy Recommenders x Software Engineers) aims to develop methods to improve the trustworthiness of RSSEs. More specifically, the TRex-SE contributions are related to: The development of vulnerability and privacy-aware miners able to create training sets for RSSEs; The conceptualization and instantiation of a trustworthiness model for RSSEs; and The definition and development of trustworthy RSSEs that leverage the aforementioned trustworthiness model and are also able to capture (and leverage) developers' feedback during development. The TRex-SE output, beyond scientific publications, will consist of open-source toolsets. Such toolsets will foster the trustworthiness of RSSEs, and favor their adoption in industrial contexts.

Jan 2025 - Present Mosaico Horizon Europe Project - In a world that demands faster development of better software, MOSAICO seeks to conciliate software engineering and the use of generative AI through the collaboration of human experts and AI agents. The project aims at producing a holistic methodology and a set of solutions for the engineering and operation of communities of AIs across the SE life-cycle. The solutions will be brought together in an integrated MOSAICO platform, handling communication, orchestration, governance, quality assessment, benchmarking and reuse of AI agents. MOSAICO will be integrated with existing development environments, to present the results to software engineers, and allow expert users to intervene in the AI decisions.

5 Teaching Activities

Academic year 2024/2025

- Laboratorio di programmazione ad oggetti. Università degli Studi dell'Aquila, Corso di Laurea in Informatica, (esercitatore – 20 hours).

6 Organization And Participation Of International Conferences And Workshops

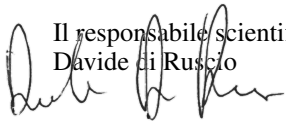
6.1 Event Organization

- **Organizer** Co-Organizer of the 1st International Workshop on Multi-Agent Systems using Generative Artificial Intelligence for Automated Software Engineering (Co-located with ASE 2025).
- **Organizer** Co-Organizer of the 1st Workshop on Generation of Synthetic Datasets for Information Systems (Co-located with CaiSE 2025).
- **Organizer** Co-Organizer of the 1st Workshop on Large Language Models For Generative Software Engineering (Co-located with Staf 2025).
- **Organizer** Co-Organizer of the 1st Workshop on Evaluation of Qualitative Aspects of Intelligent Software Assistants (Co-located with EASE 2025).

6.2 Journal Editor Participation

- Guest Editor Special issue of the Automated Software Engineering Journal - Evaluation of Qualitative Aspects of Intelligent Software Assistants 2025.

Il responsabile scientifico
Davide Di Ruscio



L'Aquila, 08 Settembre 2025
Riccardo Rubei

