Autonomous Coding Agents for Software Development: Multi-Agent Orchestration and Reinforcement Learning for Adaptive Code Generation

Abstract

This research proposes a novel framework for autonomous coding agents that collaboratively generate, debug, and validate software through agentic workflows powered by large language models (LLMs). The study seeks to advance the field of AI-driven software engineering by integrating reinforcement learning (RL)-based post-training, retrieval-augmented generation (RAG), and cooperative multi-agent decision making. The primary goal is to design a system where multiple specialized agents—such as a planner, coder, and tester—interact under a shared goal structure to create verifiable and maintainable software autonomously. By incorporating feedback loops, code evaluation, and human-in-the-loop learning, this project aims to achieve adaptive performance improvement across diverse programming environments.

Research Objectives

• Develop an architecture for distributed LLM-based coding agents capable of collaborative reasoning and task decomposition.

• Design a multi-agent coordination protocol for role assignment (e.g., planner, coder, critic) with dynamic role reallocation using reinforcement signals.

• Integrate retrieval-augmented generation (RAG) pipelines for grounding the agents' outputs in real-world codebases and documentation.

• Evaluate system robustness and scalability using empirical benchmarks (e.g., HumanEval, CodeXGLUE, SWE-Bench).

• Investigate human-in-the-loop fine-tuning to align agent decisions with developer intent and ethical coding standards.

Methodology

Phase 1: Prototype Development - Construct a baseline multi-agent system using open-source models (Gemma-3, Mistral) integrated through LangChain and LlamaIndex.

Phase 2: RL-Based Optimization - Apply RLHF or direct preference optimization to enhance collaboration and code correctness.

Phase 3: Testing and Evaluation - Benchmark the framework against existing autonomous coding systems (e.g., CodeAgent, SWE-Agent).

Phase 4: User Study - Conduct controlled experiments with graduate developers to assess system usability and explainability.

Expected Contributions

• A scalable multi-agent coding framework for autonomous software generation.

• Novel RL coordination strategies for improving agent interaction and adaptability.

• A benchmark suite and dataset for evaluating multi-agent software engineering systems.

• Publications in top-tier AI and software engineering venues (e.g., NeurIPS, ICLR, ICSE).

Alignment with OU Expertise

This proposal aligns closely with OU research in Data Science and Analytics (Prof. Jie Cao – LLM trustworthiness, dialogue systems), Industrial & Systems Engineering (Prof. Kash Barker – complex systems, optimization), and Computer Science (Prof. Charles Nicholson – metaheuristics and multi-agent modeling). Their combined expertise supports the interdisciplinary integration of AI, optimization, and systems design required for autonomous coding frameworks.

ARMAN RADMANESH

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Master's student in Data Science and Analytics at the University of Oklahoma and current Graduate Research Assistant. Experienced in cloud computing, web development, and software engineering, with a focus on building scalable, user-focused applications. Skilled in large language models (LLMs), including running, fine-tuning, and developing pipelines for multi-agent systems, automated testing, and benchmarking, as well as working with modern frameworks and cloud platforms.

PROFESSIONAL EXPERIENCE

University of Oklahoma – Data Science and Analytics (Norman, OK) **2024 – present**

Graduate Research Assistant (GRA)

Since 2024, I have served as a Graduate Research Assistant in the University of Oklahoma's Data Science and Analytics department, contributing to outreach by managing social media platforms, conducting interviews with students and faculty, assisting with event planning, and enhancing the department's visibility through updates to its official website. Currently, as part of the OUNLP group, my research focuses on multi-agent code generation and automated testing, where I research on agent workflows, develop evaluation pipelines, and explore methods to improve the robustness and reliability of automated testing systems.

New School for Social Research (Gorgan, Iran & Norman, OK) **2022 – 2025**

Senior Software Developer / Researcher

Jamasp – https://jamasp.app | Lens (Cut) – https://cut.social

As a volunteer developer and research collaborator, I led the design and implementation of two integrated platforms for behavioral and cognitive research:

- Jamasp is a secure, scalable research management system for studies involving wearable devices, offering participant management, sensor data formatting, and AI-enabled analysis tools.
- Lens (Cut) is a mobile-friendly experimental toolkit built with ReactJS and MongoDB, supporting advanced behavioral paradigms such as the ultimatum game, memory tests, and studies on the cognitive effects of fasting during Ramadan. The platform emphasizes usability and adaptability for online and mobile-based research.

Freelance Software and Web Developer (Tehran, Iran & Norman, OK) **2006 – 2024**

I have developed a wide range of web applications using Java, ReactJS, PHP, Static Websites, Google Cloud Platform, and much more. These experiences have allowed me to showcase my expertise in building dynamic and responsive digital cloud-based solutions.

BongaMonga® (Tehran, Iran) **2015 – 2018**

Senior Software Engineer / Developer

As senior web developer and web designer, I developed BongaMonga®, a real estate web application that connected customers directly with sellers/renters. Utilized Play! framework 2.x and Bootstrap 4.x for UI/UX.

WhiteOx (Rasht, Iran) **2015 – 2018**

Senior Software Engineer / Developer

I designed and implemented a multiplayer card gaming web app UI from scratch. I also developed a desktop application akin to a simplified version of PokerTracker, and a dynamic prize system, increasing ROI growth to over 100% within a year.

Ratnic (Tehran, Iran) **2014 – 2015**

Senior Software Engineer / Developer/ Co-Founder

I developed a social platform where users could compete by completing quizzes. I also designed the architecture and supervised the development of an optimized airplane ticket search engine.

IRS (Tehran, Iran) **2013 – 2014**

Software Engineer / Developer

I designed and developed a front-end web-application for "Clonet"; a firewall appliance solution.

ICT Research Institute (Tehran, Iran) **2012 – 2013**

Research Engineer / Developer

I developed experimental knowledge engineering and semantic methods, primarily focused on ontology and logic.

SELECTED PROJECTS

- Involved in Brain-Computer Interfaces (BCI) studies and conducted experiments with EEG/BCI headsets (2011-2013).
- Conducted experiments on joint arm robots using LEGO MindStorm NXT as a personal curiosity and hobby in 2007.
- Developed a Reversi player agent using Ant Colony Optimization (ACO) technique as part of an Artificial Intelligence course in 2006.
- Developed a Subscription Management System for Badbadak Magazine as a volunteer project in 2005.
- Developed a vector-based search engine called CG125 as part of an Information Retrieval course in 2004.

EDUCATION

The University of Oklahoma (Norman, OK) **2024-Present**

Master of Data Science and Analytics.

Amirkabir University of Technology (Tehran, Iran) **2011**

Bachelor of Computer Engineering, Minor in Information Technology

Thesis: Design and implementation of a wireless sensor network simulator GUI.

PROGRAMMING AND LANGUAGE SKILLS

Programming & Frameworks: Proficient in Python, Java (J2SE, J2EE, Spring Framework), JavaScript/TypeScript, ReactJS, Next.js, Node.js, Express, MATLAB, R, and C++. Skilled in web technologies including HTML5, CSS3, Sass, Less, jQuery, and modern build tools (Webpack, Grunt). Experienced with cloud platforms and development on Google Cloud Platform (GCP), Amazon Web Services (AWS), and Heroku.

Databases: Proficient in both SQL (MySQL, PostgreSQL) and NoSQL databases (MongoDB).

Machine Learning & AI: Skilled in large language model (LLM) execution, fine-tuning, and pipeline orchestration; multi-agent system development; automated testing and benchmarking; data preprocessing and model evaluation.

Other Tools & Technologies: Unix/Linux command-line tools, Git, Docker, API design, and RESTful services.

Familiar With: Blockchain concepts, Solidity, and task automation.

Languages: Proficient in English, TOEFL iBT Score: 96. Native in Farsi.

REFERENCES

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