A SURVEY ON AI POWERED SELF HEALING CODE DEBUGGER

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ABSTRACT

Software development often requires identifying and correcting errors in program code, a process known as debugging. This stage is one of the most challenging and time-consuming parts of the software development lifecycle, especially as modern applications become more complex and involve multiple programming languages and frameworks. Traditional debugging tools mainly help developers by highlighting errors or allowing step-by-step execution of programs. However, these tools still depend heavily on the developer's knowledge and experience to analyse the problem and implement a solution. This can increase development time and may be difficult for beginners who struggle to understand compiler messages or identify logical mistakes in their code.

To overcome these challenges, this project proposes an AI-Powered Self-Healing Code Debugger that uses Artificial Intelligence and Large Language Models to automatically detect, analyse, and repair programming errors. The system is designed to identify syntax errors, runtime issues, and certain logical mistakes in programs written in multiple programming languages. By examining the structure of the code and analysing execution results, the AI module generates corrected versions of the code and provides clear explanations that help users understand the cause of the error and the reasoning behind the solution. The system can also suggest improvements and programming best practices, making it useful not only for debugging but also for learning.

In addition, the platform includes a secure environment where the submitted code can be safely compiled and executed to capture runtime feedback. This helps the system produce more accurate debugging suggestions. The interface of the system is designed to be user-friendly, offering features such as syntax highlighting, theme selection, and easy copying of corrected code. By automating repetitive debugging tasks and providing clear explanations, the AI-based self-healing debugger helps reduce development time, improve code quality, and support programmers of different skill levels. Ultimately, the system aims to make debugging faster, smarter, and more accessible.

Keywords: *Artificial Intelligence*, *Self-Healing Code Debugger*, *Large Language Models*, *Automated Debugging*, *Multi-language Programming*, *Code Error Detection*, *Runtime Analysis*, *Code Optimization*.

1. INTRODUCTION

Software development has become increasingly complex due to the rapid growth of modern applications and programming technologies. As systems grow larger and more sophisticated, developers frequently encounter errors such as syntax mistakes, logical issues, and runtime failures. Traditional debugging methods require developers to manually identify, analyse, and correct these errors, which can be time-consuming and inefficient. This challenge is especially significant for beginner programmers who often struggle to understand error messages and find appropriate solutions. To overcome these limitations, intelligent debugging tools that incorporate artificial intelligence are gaining importance in modern software development.

The Self-Healing Code Debugger is an AI-powered system designed to automatically detect, analyse, and repair errors in source code. The system integrates techniques such as static code analysis, error pattern matching, and AI-based reasoning to identify potential faults and generate suitable corrections. By automating the debugging process, the system helps reduce manual effort, improve coding efficiency, and support developers in resolving issues more quickly. One of the key features of the proposed system is its ability to support multiple programming languages, allowing users to debug code written in different languages within a single platform. The system also includes a self-healing capability, where detected errors are automatically analysed and corrected with suggested fixes or regenerated code.

In addition, the platform provides a code generation feature, enabling users to generate code automatically based on a given input prompt or request. This feature helps beginners learn programming concepts while assisting developers in quickly generating functional code snippets. The system also provides customizable themes to enhance user experience and module-wise actions and access control, allowing different functionalities to be organized efficiently. Overall, the Self-Healing Code Debugger aims to create an intelligent, user-friendly environment that enhances productivity, reduces debugging time, and supports effective software development.

2. INFORMATION

Self-Healing Software Systems: Lessons from Nature, powered by AI [1]: Mohammad Baqar, Rajat Khanda, and Saba Naqvi – The authors present an AI-based framework inspired by biological healing that detects software problems, analyses system data, and automatically applies fixes to improve system reliability.

Self-Healing Autonomous Software Code Development [2]: Sandeep Kumar Jangam – This paper proposes an autonomous system that continuously monitors software behaviour, identifies faults using AI techniques, and automatically generates corrections to reduce manual debugging work.

Self-Healing AI: An Autonomous Deep Learning Approach for Software Error Correction [3]: Rupesh Kumar Mishra and Gaurav Raj – The authors describe a deep learning-based approach that detects software errors, studies program execution patterns, and automatically produces patches to correct the issues.

AI-Powered Code Generation and Debugging: A Step Towards Automated Software Development [4]: R. ThamizAzhagi and K. Thamilkani – This study discusses how artificial intelligence techniques such as machine learning and natural language processing can help developers generate code and detect programming errors more efficiently.

ChatDBG: Augmenting Debugging with Large Language Models [5]: Kyla H. Levin, Nicolas van Kempen, Emery D. Berger, and Stephen N. Freund – The paper introduces ChatDBG, a debugging assistant that combines large language models with traditional debugging tools to help developers understand program behavior and fix bugs.

Generative AI for Self-Healing System [6]: Various researchers – This work explains how generative AI can be used in self-healing systems to detect anomalies, create automated repair scripts, and maintain system performance with minimal human involvement.

AI-Driven Fault Detection and Self-Healing Mechanisms in Microservices Architectures for Distributed Cloud Environments [7]: Deepak Kaul – The author proposes an AI-based system that detects failures in microservice-based cloud applications and automatically performs recovery actions to maintain system stability.

Artificial Intelligence for Self-Healing Automation Testing Frameworks: Real-Time Fault Prediction and Recovery [8]: Prathyusha Nama, Purushotham Reddy, and Suprit Kumar Pattanayak – This paper presents an AI-powered testing framework that predicts faults during testing and automatically adapts the testing process to handle failures.

Design of AI-Powered Tool for Self-Regulation Support in Programming Education [9]: Huiyong Li and Boxuan Ma – The authors develop an AI-based learning tool that analyses students' programming activities and provides personalized feedback to improve their coding skills.

ROSE: An IDE-Based Interactive Repair Framework for Debugging [10]: Steven P. Reiss, Xuan Wei, Jiahao Yuan, and Qi Xin – This paper introduces an interactive debugging framework integrated into an IDE that helps identify faulty code locations and suggests possible fixes to developers.

Agent That Debugs: Dynamic State-Guided Vulnerability Repair [11]: Zhengyao Liu, Yunlong Ma, Jingxuan Xu, Junchen Ai, Xiang Gao, Hailong Sun, and Abhik Roychoudhury – The authors present an AI-based debugging agent that analyzes program execution states to locate vulnerabilities and automatically generate repair patches.

Explainable Automated Debugging via Large Language Model-Driven Scientific Debugging [12]: Sungmin Kang, Bei Chen, Shin Yoo, and Jian-Guang Lou – This research proposes a debugging method that uses large language models to form hypotheses about bugs, test them with debugging tools, and produce both fixes and explanations.

Teaching Large Language Models to Self-Debug [13]: Xinyun Chen, Maxwell Lin, Nathanael Schärli, and Denny Zhou – The paper presents a technique that enables large language models to analyze the results of executed code and iteratively improve their generated programs.
Fully Automated HTML and JavaScript Rewriting for Constructing a Self-Healing Web Proxy [14]: Thomas Durieux, Youssef Hamadi, and Martin Monperrus – The authors propose a system that automatically rewrites faulty HTML and JavaScript code so that web pages can continue functioning even when errors occur.
NL-Debugging: Exploiting Natural Language as an Intermediate Representation for Code Debugging [15]: Various researchers – This work introduces a debugging approach that uses natural language explanations to analyze program errors and generate possible solutions.
VDebugger: Harnessing Execution Feedback for Debugging Visual Programs [16]: Xueqing Wu, Zongyu Lin, Songyan Zhao, Te-Lin Wu, Pan Lu, Nanyun Peng, and Kai-Wei Chang – The authors present a debugging system that analyzes the execution steps of visual programs and corrects logical errors using an AI-based refinement process.
MarsCode Agent: AI-Native Automated Bug Fixing [17]: Yizhou Liu, Pengfei Gao, Xinchen Wang, Jie Liu, Yexuan Shi, Zhao Zhang, and Chao Peng – This paper introduces an AI-based agent that identifies software bugs, generates potential fixes, and verifies the corrections automatically.
LEDEX: Training LLMs to Better Self-Debug and Explain Code [18]: Nan Jiang, Xiaopeng Li, Shiqi Wang, Qiang Zhou, Soneya Binta Hossain, Baishakhi Ray, Varun Kumar, Xiaofei Ma, and Anoop Deoras – The authors propose a training framework that improves the ability of language models to explain code errors and refine incorrect programs.
AutoCodeRover: Autonomous Program Improvement [19]: Yuntong Zhang, Haifeng Ruan, Zhiyu Fan, and Abhik Roychoudhury – This study introduces an automated system that uses large language models and code search techniques to resolve software issues reported in GitHub repositories.
SELFEVOLVE: A Code Evolution Framework via Large Language Models [20]: Shuyang Jiang, Yuhao Wang, and Yu Wang – The authors present a framework where language models generate code, analyze execution errors, and refine the program iteratively to produce more accurate results.
Explainable Automated Debugging via Large Language Model-Driven Scientific Debugging [21]: Sungmin Kang, Bei Chen, Shin Yoo, and Jian-Guang Lou – This paper proposes AutoSD, a debugging system that uses large language models to analyze possible bug causes, test them using debugging tools, and generate both a program fix and an explanation of the solution.
A New Era in Software Security: Towards Self-Healing Software via Large Language Models and Formal Verification [22]: Norbert Tihanyi, Ridhi Jain, Mohamed Amine Ferrag, Yiannis Charalambous, Youcheng Sun, and Lucas C. Cordeiro – The authors introduce ESBMC-AI, a framework that combines formal verification with large language models to detect vulnerabilities, produce corrected code, and verify the repair automatically.
Thwarting Piracy: Anti-debugging Using GPU-assisted Self-healing Codes [23]: Adhokshaj Mishra and Manjesh K. Hanawal – This paper presents a GPU-based anti-debugging approach where self-healing code detects program modifications and restores the original code to protect software from piracy and reverse engineering.
Large Language Models Meet Automated Program Repair: Innovations, Challenges and Solutions [24]: Yiting Tang – This study reviews how large language models are used in automated program repair and discusses their advantages, current challenges, and possible improvements for future bug-fixing systems.
Debug Smarter, Not Harder: AI Agents for Error Resolution in Computational Notebooks [25]: Konstantin Grotov, Artem Borzilov, Maksim Krivobok, Timofey Bryksin, and Yaroslav Zharov – The authors propose an AI agent that interacts with notebook environments, analyzes runtime errors, and automatically modify or executes code cells to resolve programming issues**.**

3. CONCLUSION

The literature survey clearly indicates that Artificial Intelligence has become a powerful tool for improving software debugging, maintenance, and overall software quality. Traditional debugging methods often require significant manual effort and time, which can slow down the development process. However, recent advancements in AI technologies such as Large Language Models (LLMs), automated program repair techniques, and intelligent AI agents have introduced more efficient ways to detect, analyze, and fix software errors automatically. These technologies enable systems to identify bugs, understand their causes, and generate appropriate corrections with minimal human intervention. As a result, AI-driven debugging methods significantly enhance software reliability, reduce development time, and improve productivity in modern software engineering.

Several research frameworks such as SELFEVOLVE, AutoSD, and ESBMC-AI demonstrate how AI can be effectively integrated with software testing and formal verification techniques. These systems combine machine learning with automated testing approaches to improve the accuracy of bug detection and correction. In addition, studies show that AI-based debugging solutions are being applied in various domains including cloud computing systems, web applications, and programming education. These intelligent systems not only assist developers in identifying errors but also support learning by explaining code behavior and suggesting improvements. This highlights the growing importance of self-healing and AI-assisted debugging mechanisms in modern software development environments.

Building upon these research advancements, the proposed project "Self-Healing Code Debugging for Multiple Programming Languages" aims to develop an intelligent debugging platform capable of automatically detecting and correcting programming errors across different programming languages. The system allows users to generate programs using natural language prompts, making coding more accessible and efficient. It also supports multiple programming languages, enabling developers to work within a unified debugging environment. Additionally, the platform includes Dark Mode and Light Mode themes to enhance user experience and provide comfortable interaction during development. By combining prompt-based code generation with AI-powered debugging capabilities, the proposed system aims to simplify programming tasks, reduce debugging time, and improve code quality.

In conclusion, AI-based self-healing systems represent a significant advancement in the field of software engineering. The integration of intelligent debugging, automated error correction, and prompt-driven code generation can greatly improve the efficiency of software development. The proposed project contributes to this evolving field by providing a practical solution that supports multi-language programming, automated debugging, and user-friendly interfaces. Such systems have the potential to transform the way developers write, debug, and maintain software, ultimately leading to the development of more reliable, efficient, and intelligent software applications.

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