Project Number: 2 项目编号：2

Project Title: Automated Program Repair System Based on Large Language Models/Artificial Intelligence

项目名称： 基于大型语言模型/人工智能的自动程序修复系统基于大型语言模型/人工智能的自动程序修复系统

Project Clients: Jiaojiao Jiang

项目客户：蒋娇娇

Project specializations: Computer Science and Algorithms;Artificial Intelligence (Machine/Deep Learning, NLP);Large language model;

项目专长：计算机科学与算法；人工智能（机器/深度学习、NLP）；大型语言模型；

Number of groups: 3 groups

组数：3 组

Main contact: Jiaojiao Jiang

主要联系人：Jiaojiao Jiang

Background: 背景介绍

As the scale and complexity of software development continue to increase, fixing code defects and vulnerabilities has become an essential challenge for development teams. Traditional manual repair methods are not only time-consuming and labour-intensive but also prone to omissions, making it challenging to meet the needs of modern software development. In recent years, artificial intelligence technologies, huge language models (LLMs) and deep learning models have made code understanding and generation breakthroughs, providing new possibilities for automated program repair. Currently, the mainstream code repair methods in the industry are mainly categorized as follows: Pattern-matching-based methods: repair using predefined error patterns and repair templates, but the scope of the application is narrow. Test case-based approaches: program validation and repair generation using test cases, but relies on high-quality test suites. Machine learningbased approaches use deep learning models to learn code patterns and repair strategies, but early models have limited repair effectiveness and generalization capabilities. Large language model-based approaches utilize the robust semantic understanding and code generation capabilities of pre-trained language models, which show better potential for repair. In such a context, developing an automated project repair system based on advanced AI models has essential research value and practical significance.

随着软件开发规模和复杂性的不断增加，修复代码缺陷和漏洞已成为开发团队面临的一项基本挑战。传统的人工修复方法不仅耗时耗力，而且容易出现遗漏，难以满足现代软件开发的需求。近年来，人工智能技术、庞大的语言模型（LLMs）和深度学习模型在代码理解和生成方面取得了突破性进展，为程序自动修复提供了新的可能。目前，业界主流的代码修复方法主要分为以下几种：基于模式匹配的方法：利用预定义的错误模式和修复模板进行修复，但应用范围较窄。基于测试用例的方法：使用测试用例进行程序验证和修复生成，但依赖于高质量的测试套件。基于机器学习的方法：使用深度学习模型学习代码模式和修复策略，但早期模型的修复效果和泛化能力有限。基于大型语言模型的方法利用预训练语言模型的强大语义理解和代码生

成能力，显示出更好的修复潜力。在此背景下，开发基于先进人工智能模型的项目自动修复系统具有重要的研究价值和现实意义。

Goal: 目标
Project goals may include but are not limited to (not include all) :

项目目标可包括但不限于（不包括全部）：：

Establishing a complete project remediation process

建立完整的项目补救流程

Integrate multiple AI/large language models/deep learning models for code understanding and analyze program dependencies.

整合多种人工智能/大型语言模型/深度学习模型，以理解代码并分析程序依赖关系。

Designing model fusion strategies

设计模型融合策略

Developing model integration framework

开发模型集成框架

Implement collaborative decision-making mechanisms between different models.

实施不同模式之间的协作决策机制。

Designing dynamic model selection strategies

设计动态模型选择策略

Optimize the comprehensive evaluation of multi-model outputs

优化多模型输出的综合评估

Establish a multi-dimensional restoration quality assessment system

建立多维度的修复质量评估体系

Realize automated testing and verification mechanism

实现自动测试和验证机制

Provide manual audit interface

提供人工审计界面

Requirements and Scope: 要求和范围：

This project aims to develop an automated project repair system based on various AI/big language/ models/deep learning/machine learning models to enable the automatic detection and repair of code defects. The automated program repair system must include the modules needed to accomplish the task, and each module must be able to fulfil its responsibilities correctly.

本项目旨在开发一个基于各种人工智能/大语言/模型/深度学习/机器学习模型的自动项目修复系统，以实现代码缺陷的自动检测和修复。自动程序修复系统必须包括完成任务所需的模块，而且每个模块都必须能够正确履行其职责。

Required Knowledge and skills:

所需知识和技能

The system developed in this project needs to be able to perform automated program repair tasks. The system must input a buggy program and output code that fixes the bugs and passes validation. The system may need to include tasks such as defect detection of the code, dependency analysis of the code, and generation of program patches. Moreover, the system requires a reasonable test module to test whether the fixed code is fixed correctly or not.

本项目开发的系统需要能够执行自动程序修复任务。系统必须输入一个有缺陷的程序，并输出修复缺陷和通过验证的代码。系统可能需要包括代码缺陷检测、代码依赖性分析和程序补丁生成等任务。此外，系统还需要一个合理的测试模块，以测试修复后的代码是否正确。

Expected outcomes/deliverables:

预期成果/交付成果：

Expected deliverables include:

预期成果包括

An automated program repair system that is trained and capable of functioning and completing its tasks.

自动程序修复系统，经过培训，能够正常运行并完成任务。

Detailed developer documentation/technical documentation/user's manuals and other documentation

详细的开发人员文档/技术文档/用户手册和其他文档

Standards-compliant code comments/system demos/usage resources, etc.

符合标准的代码注释/系统演示/使用资源等。

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