**Group：Math Problem Generation**

RuiJie Hu, Oliveira ZheYuan Zhang, Blitzo

(Student ID 2130026046) (Student ID 2130026206)

abstract

In computer science, problem generator design has traditionally been constrained to specific problem types, lacking flexibility and scalability. Although traditional approaches such as template matching, database retrieval, and neural networks have their respective strengths in specific scenarios, they show limitations in achieving accuracy, generation flexibility, and scalability across different problem domains. This research introduces an innovative meta-generator framework that enables users with programming knowledge to define an arbitrary mathematical question type as a formal language through a specialized metalanguage. Thus, our generator enables the automatic construction of dedicated generators for these problem types.

This approach transcends the limitations of traditional problem generators, theoretically enabling the automated generation of all computable mathematical problems. The metalanguage is designed with formal language theory, supporting precise syntax definition, semantic rule specification, and constraint declaration. This work presents the metalanguage design principles, including grammatical rules, semantic parsing mechanisms, and the process of constructing target generators through abstract syntax trees. The framework implements a two-phase generation procedure: first generate problem-specific generators from a user-defined question type specification, then use these generators to create actual mathematical problems.

This framework establishes a theoretical foundation for problem generation and introduces a potential new paradigm for developing mathematical educational tools. The system architecture ensures extensibility through modular design, allowing for future additions of new problem types and generation strategies. Preliminary research indicates promising potential in generating specialized generators for various mathematical problems, with expected strong scalability. The approach offers significant benefits in education, providing efficient problem generation through detailed definitions and difficulty control. Furthermore, it supports difficulty customization of problem parameters while maintaining structural consistency. The framework is capable of generating structurally controlled problems, which suggests potential applications in both educational assessment and learning environments.