【Grant-in-Aid for Scientific Research(S)】
Integrated Science and Innovative Science (Comprehensive fields)

Title of Project：Higher-Order Model Checking and its Applications

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Research Area：Computer Science
Keyword：Program verification, Model checking, Type theory

【Purpose and Background of the Research】

The reliability of computer software is critical, as infrastructure such as transportation and banking systems are nowadays controlled by computers. Model checking is a promising technique for formal verification of software, but traditional model checking has a limitation in the expressive power of the mathematical models, so that it is not suitable for verification of software written in high-level programming languages.

We have recently studied higher-order model checking, and shown that (i) many program verification problems reduce to higher-order model checking, and that (ii) despite its high worst-case complexity, higher-order model checking can often be solved efficiently. Based on those results, we have constructed the first higher-order model checker and implemented an automated program verification tool. The project aims to further advance this work on higher-order model checking and program verification, and also to find new applications of higher-order model checking such as data compression.

【Research Methods】

We set up the following three sub-topics, and study them in parallel.

(1) Theory and implementation techniques for higher-order model checking: We refine model checking algorithms and implementation techniques by advancing the underlying theories for higher-order model checking. We also study open problems about higher-order model checking.

(2) Software model checkers for full-scale programming languages: We extend the prototype program verification tool to obtain a more efficient verification tool that supports full-scale programming language features.

(3) New applications of higher-order model checking: We study other potential applications of higher-order model checking, such as data compression. For example, we can compress tree data as a program that generates it, and use higher-order model checking to apply pattern matching operations on data without decompression. Data compression may also lead to discovery of knowledge hidden in data.

【Expected Research Achievements and Scientific Significance】

This project will establish a new method for software verification based on higher-order model checking, and contribute to the reliability of computer software. From a scientific viewpoint, the project will contribute to a broad area of theoretical computer science, by combining and advancing results from many fields of theoretical computer science, including formal languages and automata, type theory, model checking, program transformation, etc. The project may also influence other disciplines through applications to data compression and knowledge discovery.

【Publications Relevant to the Project】

・Naoki Kobayashi, Types and Higher-Order Recursion Schemes for Verification of Higher-Order Programs, Proceedings of the 36th ACM SIGPLAN-SIGACT Symposium on Principles of Programming Languages (POPL 2009), pp.416－428, 2009.
・Naoki Kobayashi, Model-Checking Higher-Order Functions, Proceedings of the 11th International ACM SIGPLAN Conference on Principles and Practice of Declarative Programming (PPDP'09), pp. 25 – 36, 2009.

【Term of Project】 FY2011-2015
【Budget Allocation】 105,800 Thousand Yen

【Homepage Address and Other Contact Information】

http://www.kb.ecei.tohoku.ac.jp/