Fellowship ID: BR200404

2022年　11月　01日
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独立行政法人日本学術振興会理事長　殿
To: President, Japan Society for the Promotion of Science

研究活動報告書
Research Report

1. 受入研究者/ Host researcher

受入研究機関・部局・職 Name of Host Institution, Department and Title	Tokyo Institute of Technology, Mathematical and Computing Science, Professor
受入研究者氏名 Host Researcher's Name	Hidehiko Masuhara

2. 外国人招へい研究者/ Fellow

所属研究機関・部局・職 Name of Institution, Department and Title	City University of New York (CUNY) Hunter College, Computer Science, Assistant Professor
外国人招へい研究者氏名 Fellow's Printed Name	Raffi Khatchadourian

3. 採用期間/ Fellowship Period

2022年　08月　10日　　　　　　　～　　　　　　　2022年　08月　24日

4. 研究課題/ Research Theme

Program analysis and transformations of imperative and Object-Oriented Deep Learning programs.

5. 研究活動報告/ Research Report
（1）研究活動の概要/ Summary of Research Results

Professor Masuhara and myself have been progressing on a new project involving the analysis and transformation of imperative-style and Object-Oriented Deep Learning programs. During my visit, I presented the initial idea and some preliminary results to his research group and obtained valuable feedback. We have been implementing a research prototype program analysis and transformation tool that we plan to eventually open-source and include in a joint publication. We will also use the tool to assess the approach.

Our tool approximates the run-time behavior of Python programs that produce Deep Learning models. Deep Learning is a popular subfield of Machine Learning and Artificial Intelligence. Python is a prevalent language for such programs, and precisely analyzing and safely transforming programs written in the Python programming language is challenging due to the dynamic nature of the language and a lack of a traditional compiler. Analyzing and transforming Deep Learning programs is essential to assist developers and data scientists with optimizing the run-time performance of their Deep Learning software, which typically works with extensive datasets. However, improving the run-time performance of these programs can easily result in semantically-inequivalent results, which may lead to devastating errors. When Deep Learning models are used in mission-critical applications (e.g., autonomous vehicles), the consequences can be devastating. Further challenging to the analysis' precision is the imperative style and Object-Oriented nature of modern Deep Learning software. While enabling developers and data scientists to write more reliable Deep Learning programs, the relationships between the programming language constructs complicate the analyses, making tractable analyses challenging to formulate. In our current work, we have achieved an important milestone in accurately approximating the current run-time behavior of the

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analyzed program. Understanding the current behavior is essential to improve the programs in the future. Although imperative Deep Learning programs are more accessible to write than their deferred execution counterparts, optimizing their run-time performance is non-trivial. Our current prototype can accurately determine whether a specific Python function is already optimized, which enables us to assess *candidate* Python functions. We aim to submit a complete publication to the prestigious ACM Joint European Software Engineering Conference and Symposium on the Foundations of Software Engineering (ESEC/FSE) 2023, with a deadline of January 26, 2023.

（2）研究キーワード/ Keywords

Deep Learning, dynamic programming languages, program analysis and transformation, multi-paradigm programming models.

（3）主な研究発表（雑誌論文、学会、集会、知的財産権等）/ Main Research Publications

Planned submission to The ACM Joint European Software Engineering Conference and Symposium on the Foundations of Software Engineering (ESEC/FSE) 2023 on January 26, 2023.

（4）その他/ Remarks

During my visit to Tokyo Tech and Professor Masuhara's lab, I met with all of his students and discussed their various and interesting research projects. I also visited Professor Shigeru Chiba at the University of Tokyo. I also met with Professor Chiba's students and presented preliminary results to his lab. I plan to continue interacting with both professors and labs. The opportunity to meet them in person and face-to-face in Japan was an invaluable step in initing this new and exciting project with practical application to real-world societal situations.

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