

Title	プログラム分析における木構造及びグラフ構造へ深層学習の適用
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論文題目	Applying Deep Learning on Tree and Graph Structures for Program Analysis		
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論文の内容の要旨

The rapid growth of software industry has increased a high demand for tools based on source code analysis to support developers and managers during software development. Source code classifiers are used to organize big projects or a huge amount of open source code on the web, and thus facilitate software reuse and maintenance. With a software defect prediction tool, programmers can easily locate and fix bugs. This leads to an increase in the software quality, and a decrease in the development time and product cost.

Solving software engineering problems is a big challenge. According to previous studies, programming languages contain abundant statistical properties that are difficult to capture by humans. In addition, a program may show different actions in different cases hindering us from discovering its semantic meaning. Although computers can run programs by just executing single instructions, they do not truly understand the programs. For these reasons, although many efforts have made to solve software engineering problems, the achievements are not so high. The traditional approaches build predictive models based on machine learning algorithms and handcrafted features, called software metrics. The drawbacks of such approaches are time-consuming and inaccurate because we must to manually design a set of appropriate metrics and the existing metrics are not enough to capture semantic meanings of programs. Recently, applying deep learning on tree representations to automatically learn programs' features has made a breakthrough in source code analysis. However, such trees simply reflect the program structures and do not reveal the behavior of programs. Thus, tree-based approaches may be inefficient when adapting to several tasks, especially those are relevant to an understanding of semantic meanings like software defect prediction.

In this dissertation, we focus on two main tasks: (1) proposing models and techniques to enhance existing approaches, and (2) formulating a new approach program analysis. For software metrics-based methods, we design a feature weighting model to estimate the importance extent of each metric according to its relevance to class labels. For tree-based approaches, we develop new models as well as refine data by pruning redundant

branches to boost the performance. Additionally, we propose a new approach that applies deep learning on assembly code to explore deeper into semantic meanings of programs.

Our contributions can boost the performance of current methods notably and be adapted to various problems of source code analysis.

Keywords: Program Analysis, Abstract Syntax Trees (ASTs), Control Flow Graphs (CFGs), Deep Learning, Convolutional Neural Networks (CNNs).

論文審査の結果の要旨

This dissertation focuses on solving problems of automatically detecting errors in programming languages. The thesis presents some new models and techniques for source code analysis. The first contribution is that the candidate presents a combination of feature weighting and parameter optimization which attains a significant improvement in comparison with the baseline approaches. The second contribution is that the candidate proposed a deep learning for tree structure using abstract syntax tree (AST). This method does not require feature engineering and obtains a very promising result. The third contribution is to show how deep learning model can apply for analyzing assembly code. A graph structure representation with deep learning model is proposed to deal with this matter. As a result, an efficient method is applied to deal with this problem. The thesis shows a solid and novel work for source code analysis. I evaluate the contribution of the thesis is very promising.

The candidate published two international journals and submit one international journal. He also got the best student award in the international conference.

In overall, this thesis shows an efficient approach to source code analyzing using deep learning model. The candidate shows his ability in research. The presentation in the final defense is successful. All the committee members agree that he can graduate.

In conclusion, this is an excellent dissertation and we approve awarding a doctoral degree to Mr. Phan Viet Anh.