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授与した学位	博 士
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学位論文の題目	A Study of Exercise Problems with Automatic Marking for Fundamental Programming Learning (基礎的プログラミング学習のための自動採点機能付き演習問題に関する研究)
論文審査委員	教授 舩曵信生 教授 田野 哲 教授 野上保之
学位論文内容の要旨	

This thesis presents some contributions to advance exercise problems with automatic marking for fundamental programming learning in the *Programming Learning Assistant System (PLAS)*.

Chapter 1 simply presents the background, the contributions and the contents of this dissertation. Chapter 2 overviews the Java Programming Learning Assistant System (JPLAS). The discussion covers the software architecture, the offline answering function, several types of exercise problems, and the answer analysis program. Chapter 3 proposes the Phrase Fill-in-blank Problem (PFP) in the C Programming Learning Assistant System (CPLAS) for learning C programming. PFP Instances covering basic grammar topics, logic functions, and recursive functions were generated using the PFP generator implemented by Python. The application results to 69 students confirmed the proposal's effectiveness and revealed specific weaknesses in students' C programming study. Chapter 4 presents two implementations in JPLAS. One is the PFP for test code reading studies. The average correct answer rate of all students was 95.25%, indicating the instances have a moderate difficulty level for them. Another one encompasses GUP, VTP, MCP, EFP, CCP, and PFP instances to a Java programming course at Okayama University. The results revealed the difficulty difference among the six problem types and confirmed the validity in the course. Chapter 5 studies the Grammar-concept Understanding Problem (GUP) for C and Python network programming respectively. 35 GUP instances with a total of 128 questions for C and six GUP instances with a total of 44 questions for network programming learning were generated and assigned to 140 undergraduate students. The good solution results affirmed that the novices successfully grasped the meaning of crucial keywords by answering the exercise problems. Chapter 6 proposes the Value Trace Problem (VTP) for C programming. 42 generated VTP instances with 586 answer forms and four improvements for hard instances on pointer and algorithms were presented. The average correct answer rate of 49 undergraduate students reached 94.29%, whereas my devices for hard instances improved it by 33.26%. This confirms the proposal's effectiveness in motivating selfstudy of C programming to novice students. Chapter 7 proposes the *Comment Insertion Problem(CIP)* for five network protocols with Python. The high evaluation results from novice students confirmed the proposal's suitability for learning network programming with Python. Chapter 8 proposes the Constant Modification Problem (CMP) for Scratch learning. Each question in a CMP instance asks to answer the modification of a constant in the code. The user interface, the generation process, and five CMP instances using five Scratch games were presented. The evaluation will be part of future work. Chapter 9 reviews related works in literature. Finally, Chapter 10 concludes this thesis with future works.

論文審査結果の要旨

In this thesis, the applicant presented six contributions to advance exercise problems with automatic marking for fundamental programming learning in the Programming Learning Assistant System (PLAS).

First, she proposed the Phrase Fill-in-blank Problem (PFP) in the C Programming Learning Assistant System (CPLAS) for learning C programming. PFP Instances covering basic grammar topics, logic functions, and recursive functions were generated using the PFP generator implemented by Python. The application results to 69 students confirmed the proposal's effectiveness and revealed specific weaknesses in students' C programming study. Second, she presented two implementations in JPLAS. One is the PFP for test code reading studies. The average correct answer rate of all students was 95.25%, indicating the instances have a moderate difficulty level for them. Third, she studied the Grammar-concept Understanding Problem (GUP) for C and Python network programming respectively. 35 GUP instances with a total of 128 questions for C and six GUP instances with a total of 44 questions for network programming learning were generated and assigned to 140 undergraduate students. Fourth, she proposed the Value Trace Problem (VTP) for C programming. 42 generated VTP instances with 586 answer forms and four improvements for hard instances on pointer and algorithms were presented. The average correct answer rate of 49 undergraduate students reached 94.29%, whereas my devices for hard instances improved it by 33.26%. Fifth, she proposed the Comment Insertion Problem (CIP) for five network protocols with Python. Sixth, she proposed the Constant Modification Problem (CMP) for Scratch learning. Each question in a CMP instance asks to answer the modification of a constant in the code.

The applicant has published three journal papers and 10 international conference papers to present the contributions. From the overall evaluation of this thesis, the applicant has satisfied the qualification condition for the doctor degree in Engineering from the Graduate School of Natural Science and Technology at Okayama University.