Mining Learners' Behavioral Sequential Patterns in a Blockly Visual Programming Educational Game

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***Abstract*—Previous researches have claimed that visual programming environments are helpful for learning programming by problem-solving. The purpose of this work is to use a blockly visual programming educational game for university students and analyze their sequential learning behaviors. The study presented a two-level sequential pattern mining algorithm to mine the students' behavioral patterns.**

Keywords—sequential pattern mining; visual programming environments; educational games; learners' behavior

I. INTRODUCTION

Previous researches have claimed that visual programming environments are helpful for learning programming by problem-solving. Chao in his research [1] used cluster analysis to find the students' programming learning patterns. His purpose is to identify different types of user behaviors. There are various methods for exploring user behaviors according to the application domains and purposes. Sun et al applied lag sequential analysis to mine learners' sequential patterns when taking a game-based anti-phishing course [2]. They also considered learners' flow experience to enhance their learning performance. In Zhang's study [3], they proposed a situational analytic method for predicting users' intention in multimedia social networks. For obtaining the social behavior pattern, Pan and Wang [4] used the generalized sequential pattern algorithm (GSP) for data mining. From the literature review, we can see the power of sequential analysis for exploring user behaviors. Also, we want to know whether the operation sequences between high-performance and low-performance students are different. If this is the case, we can identify low-performance students by mining their operation log data, and teach them using better operation sequences. In this study, we use a blockly visual programming educational game for university students and analyze their learning behaviors. The study presented a sequential pattern mining algorithm to mine the students' behavioral patterns. Therefore, the research question of this study is as follows:

- What are the operation patterns of high-performance students and low-performance students when they play a visual educational game for learning programming?

II. BLOCKLY VISUAL PROGRAMMING EDUCATIONAL GAMES

Google provided a free visual coding environment called Blockly [5] for developing apps. The Blockly library enables users to edit their programs using interlocking, graphical pieces, or blocks. In this environment, common programming constructs such as variables, arithmetic and logical expressions and loops are represented in the form of blocks. One of the advantages of Blockly is that it relieves program novices of the burden of memorizing syntax.

Blockly Games [6] are educational games which were developed using Blockly user interface for learning programming. For novice programmers, Blockly Games act as appropriate starting points for learning programming. Maze is a game for students to practice the concepts of loops and branches, as shown in Fig. 1.

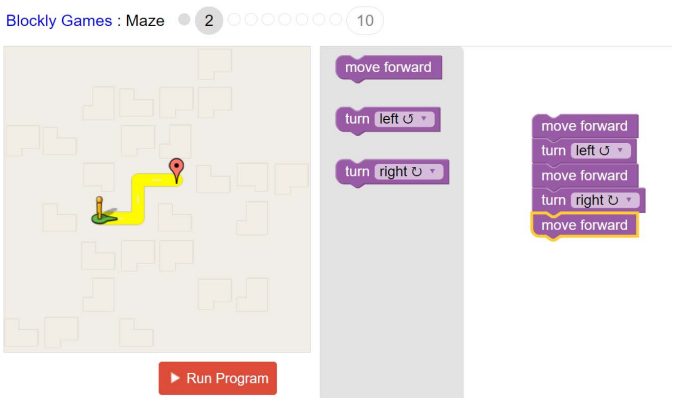

Fig. 1. The second level of the Blockly Game: Maze.

III. TWO-LEVEL SEQUENTIAL PATTERN MINING

A number of educational researches use temporal analysis methods to investigate students' behaviors. Two common approaches can be found in the literature. One approach is lag sequential analysis [7]. The other approach is sequential pattern mining [8]. Basically the former is a macro view, while the latter is a micro view. In this work, we combine the two approaches to propose a two-level sequential pattern mining method, as shown in Fig. 2. Level 1 is called Operation Level, and Level 2 is called Action Level. Users'

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operation records, such as "Adding a block," are logged in the Operation Dataset. Users' Action records, such as "Programming Blocks," are logged in the Action Dataset. In this example, "Adding a block" is a special case of "Programming Blocks." In general, an operation is a special case of an action. The Operation Dataset is pre-processed and transformed into the higher-level Action Dataset. The algorithms of Level 1 mining and Level 2 mining are designed based on the well-known GSP sequential pattern mining algorithm [9, 10]. The GSP algorithm is a multi-pass procedure like Apriori algorithm. In the first pass, large candidate set of length 1 is generated. Next, the pass k generates large candidate set of length k. In each pass, the whole dataset is scanned to calculate the support and confidence values for every candidate sequence set.

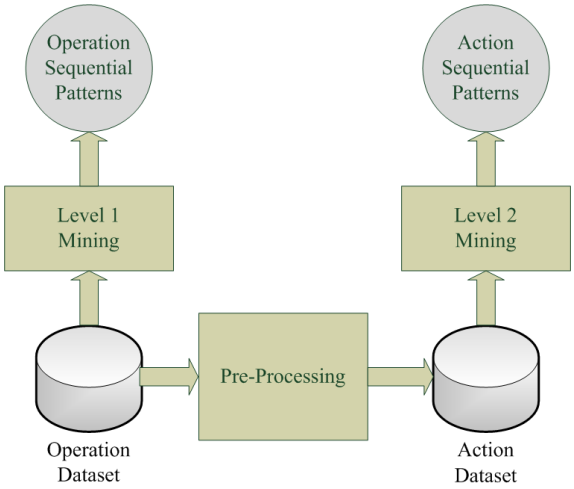

Fig. 2. The two-level sequential pattern mining method.

IV. Preliminary Results

45 university students participated in this experiment. They logged in and played the Maze Blockly Game for one hour, and their operation log data was recorded in the database. Table I shows the Actions and Operations of user behaviors collected in this experiment.

TABLE I. Action/ Operation Mapping

Id	Behavior	
	Action (Level 2)	***Operation (Level 1)***
1	Programming Blocks	Adding a Block Moving a Block Removing a Block
2	Running a Program	Running a Program Resetting a Program
3	Responding a Hint	Responding a Hint with OK Responding a Hint with Cancel
4	Choosing a Level	Choosing Level 1 … Choosing Level 10

At first, the 45 students played the Maze Game, and they were divided into three groups according to the number of levels they completed. The students who completed more than 7 levels are called high-performance students. The students who completed less than 3 levels are called low-performance students. The log data of both the high-performance and low-performance students was analyzed to obtain their sequential patterns respectively.

For the high-performance students, the most frequent sequential pattern of Action is "Programming Blocks -> Running a Program -> Responding a Hint." This pattern means the high-performance students play the Maze game smoothly through the successive levels. In contrast, the most frequent sequential pattern for the low-performance students is "Programming Blocks -> Running a Program -> Choosing a Level." This pattern means the low-performance students fail some level in the Maze game and go to other levels.

V. Conclusion

This study analyzed participating students' operation log data in the Maze game. This study proposed to use a blockly visual programming educational game for university students to analyze their learning behaviors. The study presented a two-level sequential pattern mining algorithm to mine the students' behavioral patterns. The preliminary results showed that the proposed algorithm can find behavior patterns of high-performance students and low-performance students. In the future work, more experiments will be conducted to evaluate the proposed approach.

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