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Method for Estimating Learning Strategies from Tools Using Bayesian Network

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Abstract: With the recent development of the robot technology, teacher robots will be introduced into educational settings to instruct learners. Such teacher robots, like human teachers, will be required not only to teach knowledge to learners, but also to monitor their learning process and motivate them. Positive learning attitudes can be ascertained by changing the learning strategy. The fact that learners change their learning strategies may indicate that they are making efforts to find an appropriate strategy. The learning strategies used by learners can be inferred from the tools they use to learn. Therefore, we propose a method to estimate learning strategies using Bayesian networks when learners change them.

Keywords: learning strategy, teacher robot, motivation, Bayesian Network

1. Introduction

In the future, it is expected that robots will play an increasingly important role in education, such as to provide lessons to learners. Such teacher robots will be required to provide instruction equivalent to that of a human teacher.

When human teachers teach, they not only impart knowledge to learners, but also they often motivate learners to study. One of these efforts is to provide instruction that increases the learner's motivation. In the future, such instruction will also be required for teacher robots. However, current robot-based instruction focuses only on knowledge teaching (Ono et al. 2019, Tanaka & Matsuzoe, 2012), and there are few examples of instruction that is oriented toward motivation. Therefore, this paper proposes a method for robot teachers to enhance learners' motivation.

One of the methods for enhancing the motivation is to evaluate the learner's effort and ingenuity in the learning activity and praise them. The effort and ingenuity are often appeared as changes in learning methods during the learning process, so it is required to grasp the changes in the learner's learning methods.

For a robot teacher to read changes in a learner's learning method, it is necessary to estimate changes in the learning method from what the robot can observe. Therefore, the research questions for this study are as follows:

- What observable information can be used to estimate changes in learning methods?
- How to estimate learning methods using these observables tools?

Usually, learners use learning tools, such as notes, pencils, and rulers, and such tools are fixed according to the learning methods. Based on this consideration, this studyfocuses on the learning tools as observable information of the robot and proposes a method for estimating changes in the learning method from them.

2. Overview of Learning Method Estimation System

The learning method is a pair of learning strategies and learning means. A learning strategy is a way for learners to approach learning in order to achieve their learning goals. An example of strategies is "memorizing" when the learning goal is to learn English words. In order to

practice the learning strategies, the learner selects a learning means, such as "writing repeatedly" for the strategy "memorize." Many of the learning means use tools. For example, to achieve the means of "writing repeatedly," a pencil that can be used for writing, and to achieve the means of "divide into sections," a multi-color pen that can mark the segmented items in different colors might be used as tools. Therefore, the learning method, which is a pair of strategies and means, is characterized by the tools.

In this study, for the teacher robot to estimate the learning method, Tools-means-strategies model, which represents the relationship between tools, means, and strategies, is introduced. By observing the tools through the sensor, the learning means and the learning strategies that are currently taken are estimated by using Tools-means-strategies model.

As the first step of realizing such teacher robot, we construct a system that corresponds to a function that identifies the current learning means and learning strategy. An overview of the proposed system is shown in Figure 1. The system has Tools-means-strategies model and a learning record that stores the history of the learner's learning strategies. When the user of the system inputs the tools that a learner used for the learning, instead of observing it using the sensors, the learning method identification function estimates the learning strategy based on Tools-means-strategies model and stores it as a learning record.

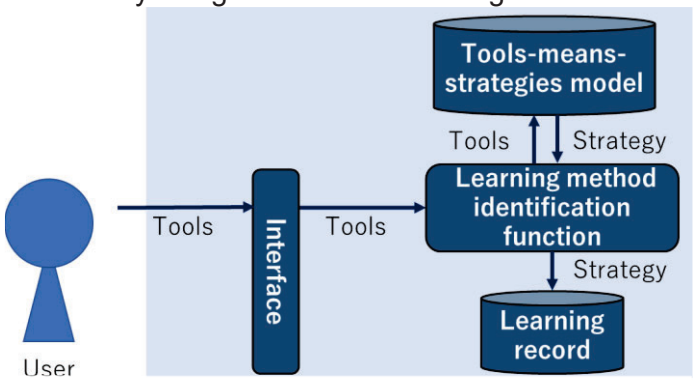

Figure 1. System Configuration

3. Method for Estimating Learning Strategy

3.1 Tools-means-strategies Model

Tools-means-strategies model proposed applied Bayesian networks to represents the causal relationship between the strategy and the means, and between the means and the tool. A Bayesian network represents causal inference by means of a directed acyclic graph structure, where nodes represent variables and links represent probabilistic correlations among variables. Each node has a corresponding choice, each of which has a probability that the choice will be chosen when a superior node makes a decision. Each alternative within the same node is exclusive and does not occur simultaneously.

In the Tools-means-strategies model, the nodes are the strategy, the means, and the tool, and the links exist between the strategy and the means and between the means and the tool. When multiple tools are used at the same time, the set of tools are regarded as a single tool. Figure 2 shows an example of Tools-means-strategies model for English vocabulary learning.

Strategies

Strategies	
Memorize	0.8
Analyze the structure	0.2

Means

Means/Strategies	Memorize	Analyze the structure
Divide into sections	0.1	0.4
Write repeatedly	0.9	0.6

Tools

Tools/Means	Divide into sections	Write repeatedly
Pencil Notebook	0.7	0.9
Multi-color pen Dictionary Notebook	0.3	0.1

Figure 2. Example of Tools-means-strategies Model

3.2 Learning Method Identification Function

The learning method identification function uses the Tools-means-strategies model to estimate the current strategy of the learner based on the input tools. The probability of each strategy is calculated from the model, and the strategy with the highest calculated value is determined to be in use. The probability that a learner is using a certain strategy A when a tool B is observed is calculated by the following formula.

$$
\begin{aligned}
&(Probability\ that\ a\ learner\ uses\ strategy\ A\ when\ a\ tool\ B\ is\ observed) \\
&\quad = (Probability\ of\ using\ strategy\ A) \\
&\quad * \sum_{all\ means} \{(Probability\ of\ using\ each\ means\ when\ using\ strategy\ A) \\
&\quad * (Probability\ of\ using\ \ tool\ B\ when\ using\ each\ means)\}
\end{aligned}
$$

Let's consider the example using the Tools-means-strategies model shown in Figure 2. If a pencil and a notebook are observed, the probability using each strategy can be obtained by normalizing the values obtained in the following equation so that the sum is 1.

Memorize: 0.8 x (0.1 x 0.7 + 0.9 x 0.9) = 0.704

Analyze the structure: 0.2 x (0.4 x 0.7 + 0.6 x 0.9) = 0.164

Normalizing the obtained values and rounding to the fourth decimal place, the probability of using the strategy of memorizing when using a pencil and notebook is 0.811 and the probability of using the strategy of analyzing the structure is 0.189, which indicates that the learner is taking the strategy of memorizing.

4. Conclusion

In this study, we proposed a method for estimating a learner's learning strategy from the tools used by the learner. Since there is a causal relationship from strategies to means and from means to tools, Tools-means-strategies model was introduced that can infer strategies based on the causal relationships when tools are observed. Currently, we have constructed the model for English vocabulary learning based on the results of a questionnaire survey asking the strategies, means, and tools in the English vocabulary learning. In future, we need to evaluate the validity of this constructed model. In addition, we also need to develop other functions of the teacher robot.

The current system treats tools as concrete instruments. However, just as notebooks are being replaced by PC-based document creation tools in line with the recent digitalization, the tools used may change in the future. Tools have functions, and tools with the same functions are likely to be used in the same way and in the same manner. For example, a pencil and a tablet pen both have the function of writing, and a ruler and a triangular ruler both measure straight lines. By expressing the tools by their function, not by the name, Tools-means-strategies model can be used even if tools change in the future. Therefore, we need to modify the tool nodes in Tools-means-strategies model to represent the their functions, not to their names.

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