06

VAE-based individually optimized problem recommendation

Here, a moderately challenging problem for you!

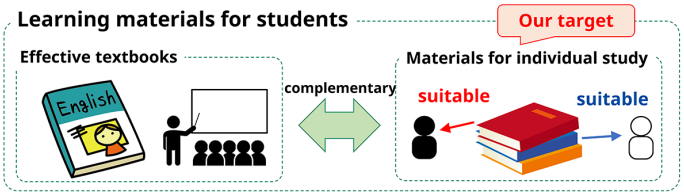
Abstract

We are researching technologies that recommend to students the optimal learning materials among many options to support individualized learning. In this presentation, we describe our novel method that predicts the probability of correctly answering a first-time problem based solely on the correct/incorrect/unanswered data of many problems by students. This technique, which is applicable regardless of the subject or type of problem, is useful for recommending moderately difficult problems based on the student's ability. We seek a future in which we can provide efficient learning for people of any learning level through technology that recommends optimal individualized learning materials.

Goal

Recommending optimal learning materials for each student

Textbooks used in classroom are not always optimal. Our goal is to identify and recommend the most appropriate materials for each student.



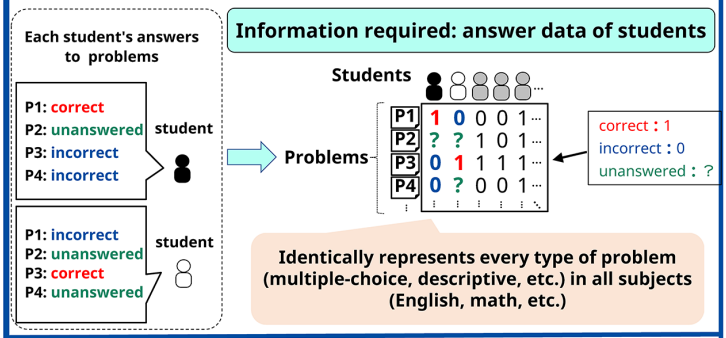
This presentation: focuses on problem recommendation and introduces a technique that recommends problems at a moderate level for each student [1].

Proposed method

We select problems that "have not been solved by a particular student" and "are expected to be solved with a designated probability."

Point 1 Applicable regardless of subject or problem type

Proposed method only uses answer data and requires no problem content.



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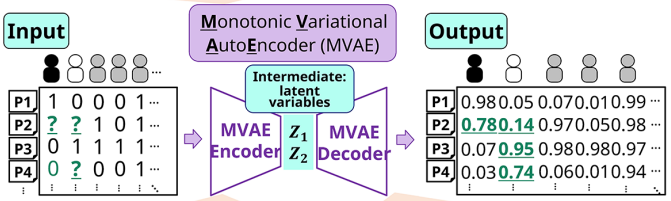
Point 2 Predicting probability that a student will correctly answer a problem first time he/she sees it.

Monotonic Variational AutoEncoder (MVAE):
predicts percentage of correct answers to unanswered problems

By training encoder and decoder to reconstruct correct/incorrect answers, MVAE **predicts probability of correctly answering unanswered problems**.



Dimensional reduction of input data, which is an answer data of many problems, to a small number of latent variables.

Reconstruction of data of same size as input from just a few latent variables

We define unanswered problems with certain predicted probability of correctly answering (e.g., near 75%) as a moderately difficult problem.

P2 Recommended to (78%)

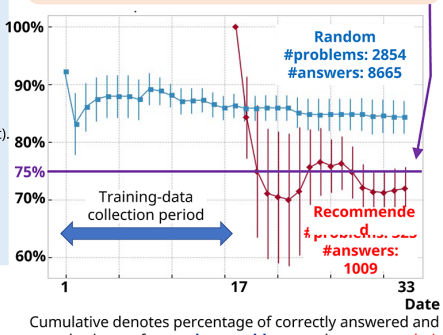
P4 Recommended to (74%)

Experimental verification

Experimental results show that predicted probability of correctly answering unanswered problems approached actual probability of correctly answering.

Purpose:
Verify accuracy of predicted correct answer probability for unanswered questions.
Participants:
18 Japanese adults (11 males, 7 females; age 20s to 50s)
Procedure (3 steps)
Data collection (16 days):
Participants given random problems online and solved as many as possible.
Interview: Participants described problems as too easy (avg. 85% correct). We considered a 75% correct answer probability more appropriate.
Verification (17 days):
Participants were given both random and recommended (predicted 75% answerable) problems in an indistinguishable manner.

Moderately difficult problems (predicted 75% correctly answerable) are successfully selected and recommended from a group of easy problems (85% correctly answered) when solved randomly by participants.



Cumulative denotes percentage of correctly answered and standard error for **random problems** and recommended problems (predicted 75% correctly answerable)

References

[1] T. Hattori, H. Sawada, S. Fujita, T. Kobayashi, K. Kamei, F. Naya, "Monotonic variational autoencoder based individually optimized problem recommender system," in Comp. Proc. 13th International Learning Analytics and Knowledge Conference (LAK23),2023.

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