WEAKLY CORRELATED ADVERSARIAL LEARNING FOR COGNITIVE DIAGNOSIS SYSTEM

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ABSTRACT

In traditional cognitive diagnosis models, the representations of students and questions tend to have a high correlation. It results in biases and poor performance in real-world applications. In order to weaken such correlation, we propose a **W**eakly **C**orrelated **A**dversarial **L**earning (WCAL) method. Based on WCAL, we design a cognitive system for both student knowledge state evaluation and exam results prediction which can help teachers select exams suitable for students. The experimental results show the proposed method can effectively model students' knowledge state and help teachers improve the teaching effect.

Index Terms— Adversarial learning, cognitive diagnosis, exam results prediction, knowledge state

1. INTRODUCTION

In real-world teaching scenarios, it is essential to let students participate in other schools' exams. But students' knowledge states in different schools are different. An exam suitable for one school's students may not be appropriate for other's. The selection of exam papers often relies on the teacher's subjective judgment, which lacks objectivity. In addition, the teacher can not estimate the difficulty of exam paper accurately. Recently, with the rise of artificial intelligence [1, 2], cognitive diagnosis has attracted more and more attention since it can be applied to predict student response. Base on the predicted results, teachers can select exams suitable for students. Therefore, it can help teachers improve the teaching effect.

However, in a cognitive diagnosis model, the representation of students and exams usually affect each other. As a result, the student latent attributes predicted by cognitive diagnosis will contain the characteristic of the question and vice versa. For example, a good student response may not be attributed to the easy exam but the student's ability. To solve this problem, in this demo, we propose **W**eakly **C**orrelated **A**dversarial **L**earning (WCAL) for cognitive diagnosis. As shown in Fig 1, by taking advantage of the adversarial learning scheme , WCAL can weaken the correlation between student and question representation and obtain precise student's latent attributes and question parameters. The obtained representations enable the teacher to evaluate the student knowledge state and exam difficulty more precisely. Moreover, the system can also predict student response, i.e., predict the exam score given certain student and exam. Based on this, our proposed demo system can provide valuable information for planning exams and teaching strategies.

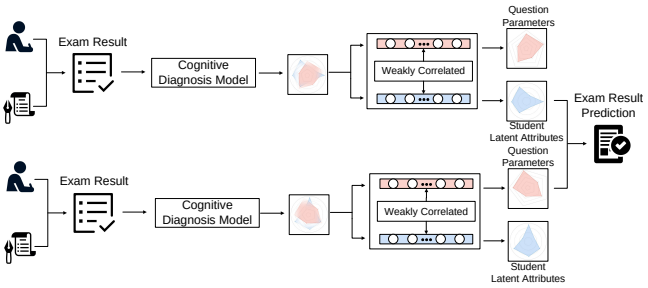

Fig. 1. The structure of the proposed WCAL model.

2. SYSTEM DESIGN

2.1. Cognitive Diagnosis

Suppose the student set is $V = \{v_1, v_2, ..., v_V\}$, the question set is $U = \{u_0, u_2, ..., u_U\}$, and the student response is Y, where $y_{i,j}$ is the result of student i answers question j. Then, as shown in Eq. 1, a cognitive diagnosis model can output a possibility $\hat{y}_{i,j}$ predicting whether the student v_i can correctly answer the question u_j,

$$\hat{y}_{i,j} = P(Y_{i,j} = 1|\theta_i, \xi_j) = f(\theta_{q_i}, \xi_{s_j}) \tag{1}$$

where θ_i represents the latent attributes of student i, ξ_j represents the parameters of question j.The cognitive diagnosis model are trained by following binary cross entropy loss function:

$$L_R = \sum_{i,j}^{U,V} y_{i,j} log\hat{y}_{i,j} + \sum_{i,j}^{U,V} (1 - y_{i,j}) log(1 - \hat{y}_{i,j}) \tag{2}$$

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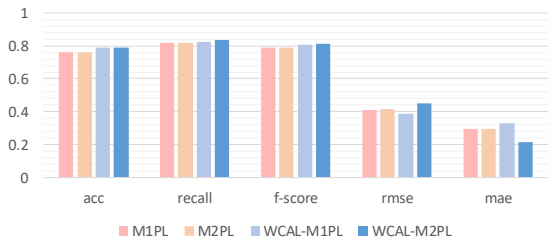


Fig. 2. Experimental results.

2.2. Weakly Correlated Adversarial Learning

After cognitive diagnosis, we can obtain optimized student latent attributes set $\theta = \{\theta_1, \theta_2, ..., \theta_V\}$ and question parameters set $\xi = \{\xi_1, \xi_2, ..., \xi_U\}$. The correlation between student and question is measured by $\theta \times \xi$. However, we find such correlation is hard to be directly minimized. Therefore we propose to use $\rho = W_\theta \times \theta \times \xi \times W_\xi$ as the correlation measure, where W_θ and W_ξ are projection matrix. To reduce the correlation between student and question, we propose the WCAL for cognitive diagnosis. First, fixing θ and ξ, we train W_θ and W_ξ by maximizing ρ. Then, fixing W_θ and W_ξ, we optimize θ and ξ by minimizing ρ. When W_θ and W_ξ project θ and ξ into another space in which ρ is maximal, it is more easy to find the minimal $\theta \times \xi$ by minimizing ρ in this space. Then the loss function of WCAL can be defined as:

$$L_{\text{WCAL}} = \min_{\theta,\xi} \max_{W_\theta, W_\xi} \rho \tag{3}$$

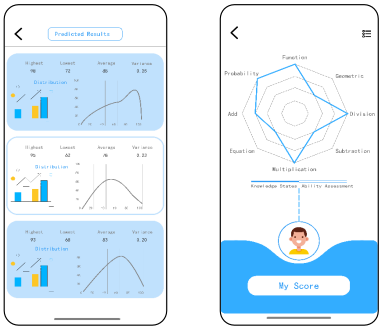
The objective function of WCAL-based cognitive diagnosis model is:

$$L = L_R + L_{\text{WCAL}} \tag{4}$$

3. SYSTEM DEMONSTRATION

We combined our proposed WCAL with two classic cognitive diagnosis models (M1PL and M2PL)[3], namely WCAL-M1PL and WCAL-M2PL. We conducted experiment on a dataset collected from a high school. The dataset contains 80 exam records of 457 students. Five evaluation metrics were used, including accuracy (acc), recall, f-score, root mean square error (rmse), and mean absolute error (mae). As shown in Fig.2, experimental results show that WCAL brings a noticeable improvement on the two cognitive diagnosis model.

The demo system is implemented in PyTorch with an NVIDIA 1080 GPU. We implemented the demo system in the form of an Android platform Application. As shown in Fig.3 (a), according to the latent attributes and question parameters, WCAL-based cognitive diagnosis system can predict student response on exams to accurately analyze the difficulty of exam papers and provide help for teachers to select suitable exam papers. In addition, based on the students' response, our proposed WCAL-based cognitive diagnosis system can estimate the student knowledge state more accurately, which is showing in Fig.3 (b).



(a) (b)

Fig. 3. User interfaces of the presented system. (a)The statistics of the predicted exams results such as average and distribution curve. (b)The student's knowledge state.

4. CONCLUSION

In this demo, we present weakly correlated adversarial learning for cognitive diagnosis system. Through WCAL, our system can effectively learn to reduce the correlation between question parameters and student latent attributes. Experimental results show that our system can outperform traditional methods. We also demonstrate that our system can provide valuable information for exam difficulty prediction and student knowledge state assessment.

5. ACKNOWLEDGEMENT

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