BETA-CD: A Bayesian Meta-learned Cognitive Diagnosis Framework for Personalized Learning

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Lecture Transcript

Hello everyone. My name is. I'm from University of Science and Technology of china. I'm glad here to present our accepted work on educational determining which is the abbreviation metal learn cognitive diagnosis framework for personalized learning.

The presentation contains four parts, the first part is background.

Personalized learning is the main component in most intelligent tutoring systems which aims to deliver customized services based on the student's personal states to address their unique needs. In study assuring the figure below each student has a few personal practice logs used to estimate his or her cognitive state, which means how well the student has mastered the specific knowledge concepts. Then the system can provide personalized services based on the diagnosis result such as online cross recommendation and learning path planning.

Compared to conventional scenarios where students are provided with equally non personalized practice questions and educational services. Personalized learning can essentially achieve lower practice burden and higher service quality.

In our research we focus on the fundamental part of personalized learning which is how to accurately obtain personal cognitive state estimation from the practice data of students. This is actually a standard psychometric task called cognitive diagnosis or C. D.

To accomplish C. D. Task. We need mathematically model the states with the so called C. D. N. For example the item response theory model uses uni dimensional continuous latent parameters to indicate to indicate student ability level and the question difficulty level respectively and model the predictive response with the logistic function.

Although existing C. D. M. S. Are effective in most applications, they face two challenges under the personalized learning scenario. First they cannot cope with data. Spar city since personalized learning requires minimum practice burden, the CTM is prone to over fit on owning a few data. 2nd, they cannot properly measure reliability because downstream applications heavily depend on the results of cognitive diagnosis. The CTM should not only output a result but also inform us of the reliability of the result.

In one word, we need a principled way of conducting city tasks in personalized learning scenarios.

To this end in this paper we propose a general aviation metallurgy cognitive diagnosis framework, better C. D. Which achieves both lower practice burden and higher service quality for personalized learning.

We first introduced variation geological modeling for the cognitive diagnosis task. To unified lee incorporate prior knowledge and the model uncertainty. Then we formulate a meta learning objective to automatically exploits prior knowledge from historical data and soviet with a scalable gradient based variation of influence method,

extensive experiments on various datasets and models validate the effectiveness and generality of better city.

Next I will introduce our method in more detail.

Our study problem can be formally formally stated as follows, suppose an intelligent tutoring system with cognitive diagnosis model parameters by theta. Given the historic students with their recorded practice data for any new students. Our goal is to obtain a personalized cognitive state estimation by a small amount of new practice data.

The key idea of our method is as follows. First to alleviate the overfitting problem caused by data scarcity of the new student. We can exploit prior knowledge from the massive data left by historical students. Secondly, to measure the reliability of the diagnosis result. We enhance the cognitive diagnosis results within a probabilistic framework. In order to quantify this uncertainty

to be more specific, our framework consists of three components. First we use aviation geological modeling to represent the prior knowledge and model uncertainty in a unified way. Second, we automatically exploit the prior knowledge from data with meta learning techniques. Third we accelerate we accelerate the algorithm with gradient based variation all influence. Let me give a further explanation. Next.

Traditionally C. D. M. Often gives a point estimation to the cognitive states while typical optimization objectives such as maximum log likelihood, such a paradigm is prone to overfitting and contains little information about reliability To this end we instead view cognitive states in the probabilistic, probabilistic perspective, Resuming parameter ized prior distribution for the cognitive state parameters and infer its posterior real distribution with variation

intuitively the prior contains some meta knowledge about the overall student population, such as average ability level. This metal knowledge is shared by all the students. In comparison the posterior reference, the personal diagnosis result which can measure the uncertainty of its own with statistical features like Andrew.

So this is basically our creation theoretical modeling. The next question is how to specify a proper prior in the literature. The prior is manually determined by experts or justice specified as a standard of caution. For simplicity,

such prior has limited the effects in preventing overfitting. Instead, we discover prior knowledge automatically from the practice data of historical students by optimized by optimizing the primary tries prior with a well formulated meta learning objective.

The key idea here is to exploit the similar structures of more city tasks for each individual student. The best prior can be found can be found by optimizing the overall performance across all tasks.

Finally the remaining problem is that the posterior is usually intractable in high dimensional space. Our solution is using a variation of distribution to approximate the posterior, which can be obtained by minimizing the KL divergence from the target distribution.

We define a local laws to approximate the personal posterior distribution for each student. Accordingly we can treat the previous meta learning laws as a global laws that is used to find a shared prior distribution with such a gradient based variation influenced technique. The two losses can be related by a gradient and thus can be both optimized efficient.

Put it together we obtain a vacation metal and cognitive diagnosis framework which we call better C. D. The matter training and the matter testing algorithms are strong below

we conduct extensive experiments to validate our proposed method,

we use three real world educational deficits with different sizes and sources to evaluate the generality of the framework. We apply better city to four types of C. D. M. S, including classical and deep models. We split 60% students as historical students for training and 20% as new students for evaluation and testing respectively. For each student we split 20% of the records validation item set

since cognitive state is hard to directly observe. We instead use student performance prediction task to evaluate the effectiveness of C. D. M. Which is essentially a binary classification task and can measure with A C. C. And A. You see metrics. In addition, we also evaluate the quality of uncertainty quantification with two matrix reliability diagrams and expected calibration error.

The overall performance comparison shows that after applying by the city on each type of C. D. M. The A. C. C. And A. U. C. Performance is greatly improved.

Further ablation study shows that both matter learning and variation geological modeling have unique impacts to the effectiveness of better city.

Finally, we show that the uncertainty information contained the investor C. D. Is much more consistent with real predictive uncertainty than that in original models.

To conclude in this work we proposed a general aviation metal and cognitive diagnosis framework, better C. D. Which unified lee addresses prior knowledge of exploitation and model uncertainty. Quantification for cognitive diagnosis. In the context of personalized learning, we firstly introduced variation geological modeling consisting of a shared prior including prior knowledge and a student specific posterior conveying uncertainty.

Furthermore we formulated a meta learning objective to automatically exploit prior knowledge and efficiently solved it with a gradient based variation, all influence method, extensive experiments have shown the effectiveness and the generality of our framework.

Thank you.