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Analysis of Digital Signal Processing Correlated Curricula Based on Fuzzy Cognitive Model*

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Abstract. The analysis of students' performance in education teaching in colleges and universities plays an important role. However, little attention is paid to these analyses in many universities so far and the existing results of analyses are not comprehensively and thoroughly enough. According to this situation, in order to help students understand their own capabilities and help teachers master students' level, this paper introduced the fuzzy cognitive model and applied it to the course of digital signal processing and other correlated curricula. We analyzed related data with the fuzzy cognitive model in multi-aspects such as the correlation between other courses and digital signal processing, the relationship between prediction results and actual results, the difference between scores of different classes, students' performance trends in different score sections. On these bases, we put forward corresponding teaching suggestions, in order to promote the teachers' teaching level and students' learning effect in the course of digital signal processing.

1. Introduction

With the modernized development of communication technology in the characteristic of digitization, digital signal processing (short for DSP), which is the basis for all kinds of new technologies in theory and technology, has developed rapidly [1-2], and is applied in engineering practice more and more widely. Accordingly, as the basic course of students in the major of communication engineering, DSP also plays an increasingly important role in specialty cultivation programme. DSP is an important professional course which is established towards undergraduate students who major in communication technology, and it puts particular emphasis on basic knowledge and physical concept, pays attention to cultivating students' innovative thinking and consciousness, as well as the ability to analysis and solves the specific engineering problems using the learnt knowledge comprehensively.

Student's score is an important index to evaluate and measure the learning effect, and the performance analysis has guidance and feedback effect in many aspects such as students' learning effect, teachers' teaching level and school's teaching administrating ability. In order to help teachers master the level and ability of students' learning, improve the teaching pertinence and quality [3], this paper made a comprehensive analysis towards students' course score in abundant levels. We use the fuzzy cognitive model to predict the students' performance creatively [4], analyze the correlation degree between DSP and other public basic courses as well as other professional basic courses, find out the related factors which affect students' performance and then, summarize the rules. Through the analysis in this paper, we can provide students reasonable improvement programs in the study of DSP, optimize the curriculum system, further perfect the specialty cultivation programme, and finally, improve the personnel training quality of students who major in communication technology.

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2. Fuzzy Cognitive Model

ITS (*Intelligent Tutoring System*) is the teaching system which use machine learning, data mining and artificial intelligence to teach learners knowledge and skills more scientifically and efficiently. It can discover the blind spots in the process of teaching and learning intelligently which teachers and students are hard to find, and develop individualized teaching on the basis of these blind spots. For the past few years, the related research and application of ITS has developed like a raging fire, such as the Cognitively Diagnostic Assessment proposed by Nichols et al. in 2012 [5], MOOC (*Massive Open Online Courses*) proposed by Anderson et al.in 2014 and so on [6]. A crucial step of these educational researches is the cognitive modeling of students, which aims at discovering the latent characteristics of students and so, to predict their performance on each problem. When what we talk about reflected into the exam, and then became the score students get on each problem. However, problems students faced with may have both objective and subjective types, previous perceptual model (PMF, DINA, IRT, NMF, etc.) performs good on objective problems, but has great limitations in the prediction of subjective issues whose scores are continuous. Therefore, we use FuzzyCDF (*Fuzzy Cognitive Diagnosis Framework*) [7] to fuzzily students' potential features, making the predicted score more close to the students' actual level.

In this way, FuzzyCDF is represented as a four-tier hierarchical model: first mining potential properties of each student; then determines students' skill proficiency; next computes students' problem mastery and finally generates students' observable scores on problems by considering slip and guess factors. Throughout this whole process, we propose a Monte Carol Markov chain (MCMC) sampling algorithm to infer the unobservable parameters of FuzzyCDF [8].

3. Correlation Analysis on Students Score Data

3.1 Collection of the Students Score Data.

Students' learning is a gradual process; there are certain orders between the courses they learnt. In this paper, we choose 86 students which from three classes in 2013 grade in major of communication engineering as the research object, extract students' score of six required courses from school score database as research samples. These courses contain DSP, public basic courses related to DSP such as Theory of Circuitry(1), Complex Function and Integral Transform, Theory of Circuitry(2), and professional basic courses such as Electronic Circuit of Communication, Signals and Systems. In specialty cultivation programme, these six courses opened in different semesters: Theory of Circuitry(1) and Complex Function and Integral Transform start in the second semester, Theory of Circuitry(2) starts in the third semester, Electronic Circuit of Communication and Signals and Systems start in the fourth semester, and finally, DSP starts in the fifth semester. This paper uses fuzzy cognitive model to extract hidden valuable information from these masses of course score data.

3.2 Analysis of Correlation Degree between DSP and Each Course.

For the other five courses in addition to DSP, we select one of them in each experiment in turn, assume this course's students' score as full marks (100 points) and the remaining four courses still be the real students' score. We use the fuzzy cognitive model to predict the students' performance on DSP in each experiment, observe changes and make correlation analysis. Specific experimental process is as follows: for the course of Theory of Circuitry(1), we first assume all students' score on this course as 100 points and the score of Complex Function and Integral Transform, Theory of Circuitry(2), Electronic Circuit of Communication and Signals and Systems still be the real one of students. Secondly, we put these five courses' score into the fuzzy cognitive model and the output will be 86 students' predicted performance of Theory of Circuitry(1) and DSP. Since each prediction results have slightly deviation, when the predicted score of Theory of Circuitry(1) is the most close to 100 points, we choose this predicted score of DSP as the best prediction result. For the rest of the four courses, the experiment is similar to above process and it's no need to be repeated here. In order to facilitate comparison, we calculated the average of all the students' predicted performance. If the students' average score in the DSP course is improved obviously under such circumstance that a specific course's score is full mark, then it indicates that this course has great influence on the course of DSP and teachers can focus their teaching on this course at the early stage of DSP's teaching. Specific experimental results are shown in Table 1 (normalization processing is carried out with the original score).

Table 1. The Influence of a Course's Full Mark for DSP.

Course whose score is assumed as full mark	Average of predicted score	Average predicted score of DSP
Theory of Circuitry (1) (2nd semester)	0.9052	0.4689
Complex Function and Integral Transform (2nd semester)	0.9542	0.9994
Theory of Circuitry (2) (3rd semester)	0.9892	0.3846
Electronic Circuit of Communication (4th semester)	0.9095	0.2580
Signals and Systems (4th semester)	0.9932	0.9926

Note: Students' actual average score of DSP is 0.7156

The following are what we can see from the results: (1) the courses of Complex Function and Integral Transform and Signals and Systems have high correlation with DSP. When we assume these two courses' score full marks, the students' average score of DSP that we predicted using fuzzy cognitive model has improved obviously(among them, when assume the course of Complex Function and Integral Transform full marks, the average score of DSP increased by 39.66%; when it turn to Signals and Systems, the average increased by 38.71%). (2) Theory of Circuitry has certain influence on DSP and it presents a progressive relationship with DSP in the cohesion of knowledge. (3) Electronic Circuit of Communication has weak correlation with DSP, and these two courses can be considered to be in parallel when making the teaching plan. Conclusively, the learning effect of Complex Function and Integral Transform and the course of Signals and Systems affect the students' performance in DSP directly. Speaking strictly for teachers, to achieve better results in the teaching of DSP, these two courses' teaching work must be enough emphasized at the early stage.

3.3 Analysis of Prediction Performance and Actual Results in DSP.

In the students score dataset mentioned above, we extracted a total of 86 score data of DSP as DSP data set. With the fuzzy cognitive model, we did the prediction of 86 students' DSP score, and then, we calculated the error of prediction results and actual results on this basis by formula (1). Because of the large amount of data, we took the average processing of all actual score, predicted score and the error. By comparing the difference between prediction result and the actual result, we can be more aware of students' mastery degree on DSP. The result of this experiment is shown in Table 2.

$$\text{Error} = \frac{Prediction\,Score - Actual\ Score}{Actual\ Score} \tag{1}$$

Table 2. Contrast of DSP Prediction Result and Actual Result.

Course	Actual Score(avg.)	Prediction Score(avg.)	Error of Actual and Prediction Score
DSP	71.65	86.37	0.2054

We can see from the table that, there is a certain difference between the predicted score using fuzzy cognitive model and the actual one on DSP, and the error can be up to 0.2054. By analyzing the students' potential ability and combining with the related knowledge, the fuzzy cognitive model thinks that students can perform much better on the study of DSP. So, from a side, it reflects that it leaves much to be desired in aspects of knowledge structure arrangement, teaching methods and instructional strategies. In the subsequent teaching process, teachers can establish teaching scheme which is more suitable for students, so as to improve the teaching pertinence and quality.

3.4 Analysis of Student's Performance in Different Classes.

Total dataset was divided into three subsets according to the class. In each subset, we predict each course's prediction performance with fuzzy cognitive model and calculate the error of prediction and actual performance. The results are shown in Fig. 1, where the horizontal axis represents course name: 1-Theory of Circuitry (1), 2-Complex Function and Integral Transform, 3-Theory of Circuitry (2), 4-Electronic Circuit of Communication, 5-Signals and Systems, 6-DSP, and the vertical axis represents the error.

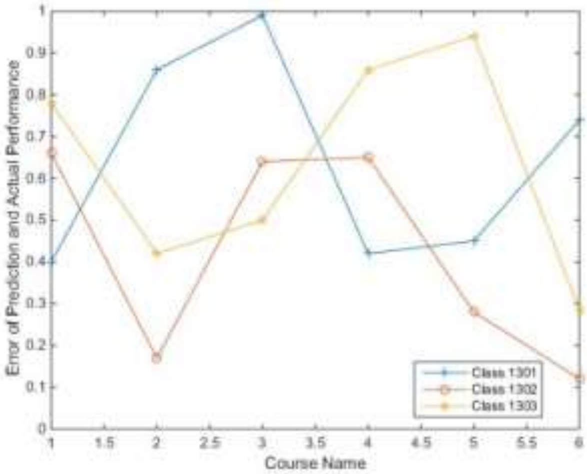

Figure 1. Error contrast of prediction and actual performance in class 1301-1303.

Environment has strong influence on a person's development; the study atmosphere also has certain influence on students' achievement. We compared the score of three classes and so we can analyze the difference between different classes. From Fig. 1, class 1302 has the minimum error in course of DSP, followed by class 1303, and the maximum error appear in class 1301. The smaller the error is, the closer the actual teaching effect and the ideal teaching effect. This shows that for the course of DSP, class 1302 performs best among three classes, besides; class 1303 and 1301 should fill in the parts of its lineup where it is weak. Through comparing the practical situation such as the average score and flunk rate, we verified the reliability and worthiness of these experimental results.

3.5 Analysis of Student's Performance Trends in Different Score Sections.

Firstly, we reranked the DSP score for all students in descending order and divided it into seven bands(above 95 band, 90-95 band, 80-90 band, 70-80 band, 60-70 band, 50-60 band and below 50 band). Secondly, extract a student in each band respectively to represent all the other students in this band. Finally, extract other five courses' score of these seven students to observe and analyze, and the results are shown in Fig. 2. Same as Fig. 1, the horizontal axis represents the course name: 1-Theory of Circuitry (1), 2-Complex Function and Integral Transform, 3-Theory of Circuitry (2), 4-Electronic Circuit of Communication, 5-Signals and Systems, 6-DSP, and the vertical axis represents the score students got on this course.

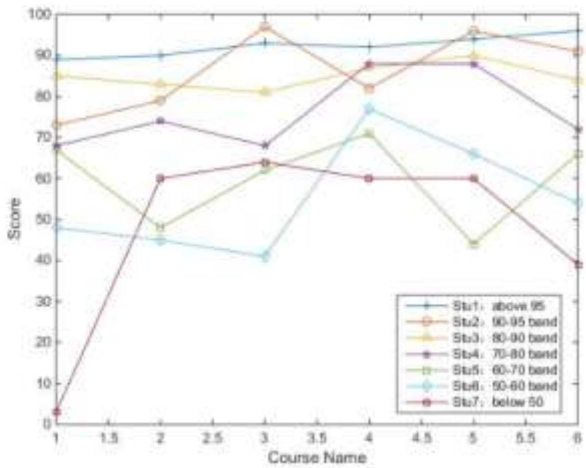

Figure 2. Performance contrast of students in different score sections.

This figure tells us that, the students who have mid-high points (above 70 points) in DSP, also perform well on other subjects and they have slight variation. However, students whose DSP point belongs to low levels (below 70 points), especially below 50 points, usually have unsatisfactory performance in other subjects. In some ways, on behalf of students overall level, the analysis of performance in DSP has important significance in the process of education.

4. Suggestions to Improve DSP Teaching Quality

Finding the way to perfect the state of DSP teaching, improve the teaching quality, cultivate students who can meet the demand of the industry with high quality and strong capability, is the explore purpose of this paper. On the basis of the above analysis, we put forward the following several suggestions:

1. Strengthen the course construction which has significant effect on DSP. For these two courses, Complex Function and Integral Transform and Signals and Systems, they have high correlation with DSP and students widespread have low average score and high flunk rate. Teachers should according to the data feedback results, on the basis of understanding students learning difficulties and professional requirements, perfect the knowledge structure, improve teaching methods, increase the tutorship, and provide a solid theoretical basis for the study of follow-up professional courses.

2. Make the curriculum setting of specialty cultivation programme more reasonable. It can be seen from the analysis of correlation degree between DSP and other courses that, the current arrangement of courses is basically reasonable. Yet, there can be some adjustment of the term that Electronic Circuit of Communication opens. In simple words, it can be considered to be opened at the same semester with DSP.

3. Teach students in accordance with their aptitude, provide personalized teaching plan. In the aspect of teachers, they can adjust the teaching plan, put the emphasis on students’ weak links and improve the teaching pertinence. In the aspect of students, teachers can understand the strengths and deficiency through the analysis of student's performance in different score sections, and then put forward the personalized guidance suggestions. Provide more opportunities to attend course contests for the students in mid-high bands, encourage them to form scientific research team and provide the corresponding guidance. Meanwhile, these data can help to find the students who need special attention and finally realize the specialization teaching.

4. Pay attention to strengthening the construction of academic atmosphere. At the analysis of each class, teachers should catch sight of the difference of academic atmosphere and mental outlook behind the data between different classes. The environment has imperceptible influence on people. The ideal academic atmosphere where curiosity-driven exploration is encouraged can promote student's spontaneity and proactivity; meanwhile; essentially create the largest possibility to improve student academic performance.

5. Conclusion

In this paper, we use the fuzzy cognitive model to predict the students' performance creatively, analyze the interrelation between DSP and other public basic courses as well as professional basic courses, summarize the regularity and give some suggestions. We aim at finding the gap between student's predicted score and actual score and finally, improve student's academic performance and comprehensive quality. However, this paper only picked a part of data that have impacts on DSP so there must be some limits. In the follow-up of the study, we can extend the data to the subsequent courses; make the mining and analysis more comprehensive and in-depth.

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