Teaching methods for the course *Artificial Neural Networks and Applications*

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ABSTRACT: Artificial Neural Networks and Applications is a postgraduate course in the control science and engineering discipline in China. The course involves complex theory and draws on knowledge from many disciplines. Traditional teaching of the course is not as effective as it might be. In order to improve the teaching and to cultivate talent with innovative ability, the use of case teaching to reform the teaching method is reported in this article. The current teaching is reviewed, followed by a discussion of case teaching design principles and implementation. Then, the specific case base developed for the course is described. Practice shows that case teaching improves the students' ability to analyse and solve problems, and improves the quality of teaching.

INTRODUCTION

Artificial neural network control is an advanced control technology at the forefront of the discipline of automatic control. It can be used to solve complex control problems involving nonlinearity and uncertainty, and has broad application in the fields of automation, machinery, the chemical industry, and so on [1-3]. Neural network control, which combines artificial neural networks with control theory, is a rapidly developing discipline that combines mathematics, biology, neurophysiology, brain science, genetics, artificial intelligence, computer science and automatic control. Artificial neural network control has developed only recently, involves many disciplines with deep theoretical underpinnings, and so is not easy to understand.

Artificial Neural Networks and Applications is an important postgraduate course for students of control science and engineering in China. The traditional teaching model for this course is for the teacher to lecture first, followed by the students performing experiments. Many teachers focus on systematic and complete basic knowledge with an emphasis on concepts and theories. Therefore, most students are cast in a passive mode. At the core of the experiments is the verification of teaching content; so students just copy from the textbook. This traditional teaching mode limits a student's ability to solve practical problems, and is bad for the cultivation of innovative talent. As the teaching progresses, students become bored and lose interest in the course. Hence, it is necessary to reform this existing teaching mode and to improve the quality of teaching.

Case-based teaching is an active learning method that can improve a student's ability to analyse practical problems [4-6]. Case studies are used to describe the actual questions addressed by the teaching. This method can assist students to discuss and summarise the subject questions, while developing skills of active exploration and analytical thinking in a real environment. Combining theory and practice is a key objective of case teaching. Case-teaching methods have a long history in the fields of law, medicine and management science but only a short history in control science and engineering and, especially, in artificial neural network courses.

The application of case-teaching methods in management science started at the Harvard Business School (HBS). In 1910, Professor E.F. Gay suggested to Dr M.T. Copeland that student discussion should supplement classroom teaching. From 1909 to 1919, managers were invited to present management questions during class time. Students analysed these questions and produced recommendations for dealing with the questions. Dean W.B. Donham was a Harvard-trained lawyer educated by the case-based method. He actively promoted the use of case-teaching methods in HBS during his time as dean. With his strong encouragement, in 1921 M.T. Copeland published the first HBS casebook, *Marketing Problems*. It lays the foundation for the use of case teaching in management science. As case teaching goes against traditional teaching methods, a long period had to be spent in popularising the use of case teaching in American

management education. Through to the 1950s and 1960s, HBS gradually established a consensus for the significance, characteristics and effectiveness of case teaching and, hence, laid the foundation for its development.

The application of the case method has been used for only a short time in general education. American educator J.H. Shulman gave a speech in 1986, which aimed at promoting case teaching. After this, many scholars and practitioners started to use case teaching as a tool to analyse and research practical questions. Case teaching has now been applied in a variety of education and training programmes. The use of case teaching occurred relatively late in China; there are insufficient resources available for case teaching and an unevenness among Chinese academies of the quality of actual teaching.

In recent years, Chinese scholars have paid attention to case teaching, and started to research the principles, teaching goals, orientation and methods of case teaching. Artificial neural network courses have been established only recently in China and elsewhere. As a result, few cases have been compiled and the use of case teaching for these courses is only beginning.

In order to improve teaching quality and effect, case-teaching methods are widely used in the teaching of the artificial neural network course at Jilin University. This combines abstract knowledge with real cases to prevent teachers from dropping into boring, cockamamie theoretical sermons. By focusing on selected cases, students acquire new knowledge, and the methods and techniques used to solve practical problems. They do this by watching, imitating and extending cases during the class. Case teaching conforms to the cognitive abilities of human beings, and so enables students to more easily obtain new knowledge. Case teaching is a teaching mode of *learning by doing*, which can improve a student's enthusiasm and initiative by providing a sense of fulfilment by the completion of a case. With the accumulation of completed cases, students' theoretical knowledge and practical abilities gradually improve. Hence, the importance of using case teaching in the Artificial Neural Networks and Applications course.

APPLICATION OF CASE TEACHING IN THE COURSE, ARTIFICIAL NEURAL NETWORKS AND APPLICATIONS

The knowledge that students acquire from books is indirect and abstract. It is the ultimate goal in engineering education to use theory to solve practical problems, which tests a student's basic skills. The teaching goal of the course, Artificial Neural Networks and Applications, is to master neural network control theory and to learn how to apply this theory to the solving of practical control problems step-by-step. However, the content of the course is abstract and theoretical, with a wide knowledge base. The teacher might focus on theoretical concepts without relating them to practical applications. The students might understand the theory but cannot solve practical problems, which lowers their enthusiasm for learning. The introduction of case teaching can solve these problems.

Case teaching highlights the relationship between theory and practice, which makes the theory seem relevant and this, in turn, improves students' appreciation of the course. During the course, asymptotic cases are organised to give students a better understanding of each knowledge point, which improves their ability to design actual control systems. Through these cases, the basic content of control theory is systematically developed. This helps students to understand the application of control theory to actual projects. Hence, the examples deepen students' knowledge and cultivates their ability to analyse and solve problems.

MAIN CONTENT OF THE CASE-TEACHING METHOD

Principles for Designing Cases

Case selection and design should fully reflect the teaching content. The aim of case teaching is to promote a deep understanding of the course content. At the same time, the case design should stimulate a student's desire to learn, promote independent learning and improve a student's ability to solve practical problems [7].

The practicability of the case: the selected teaching case should be suited to the practical engineering application. It should make students understand the importance of, and pay attention to, the content of the learning. It, then, improves their ability to solve practical engineering problems.

The universality of the case: the modest complexity of a case is necessary, so that most students can understand the learning content. Considering the different ability levels of students, the selected cases should be comprehensive and suited for students of various ability levels.

The hierarchy of cases: a new case is based on a previously designed case. The difficulty and functionality of new cases gradually increases. This hierarchical approach cultivates the analytical and problem-solving abilities of students.

The synthesis of cases: a case may relate to a single knowledge point or be more comprehensive. A comprehensive case may cover one area of knowledge, many areas or an entire course. This can give students an overview of the course and improve their ability to apply knowledge.

Case Implementation

Students can actively analyse and discuss specific cases. This active exploration significantly improves teaching quality. The case-teaching method activity, including case analysis, case design, case demonstration and case expansion, should be student-oriented but teachers should play a leading role. Students should be introduced to more difficult problems so that they can think deeply and analyse carefully the real questions. By exploring new knowledge, analysing and solving practical problems and, finally, completing the design of a case, students can develop a framework of knowledge acquisition under the guidance of teachers or educators. Students not only understand the specific case, but also master the method of analysing and solving problems, and cultivate self-learning.

Case analysis: students should consult the relevant information related to the case by autonomous learning. During the case analysis, students should become deeply acquainted with the case. Subsequently, the resolution of the case is developed, and teachers explain the knowledge points covered by the case. A key aspect is teacher guidance of students during case analysis.

Case design: the realisation of a case requires the instruction by teachers of students to design algorithms for the case. Students verify the effectiveness of the algorithms using MATLAB [8-10] and the C++ programming language.

Case demonstration: students demonstrate their case and it is compared with standard cases. This generates a sense of fulfilment in solving the case.

Conclusion, summary and extensions: at the end of each case, teachers should conclude and summarise the knowledge used to analyse the case. It is necessary for teachers to highlight deficiencies in the design. Teachers can, then, guide students to improving their design by avoiding these deficiencies. In this way, students can cultivate their ability to analyse and solve problems, and also improve their innovative ability.

The implementation process of case teaching is shown in Figure 1.

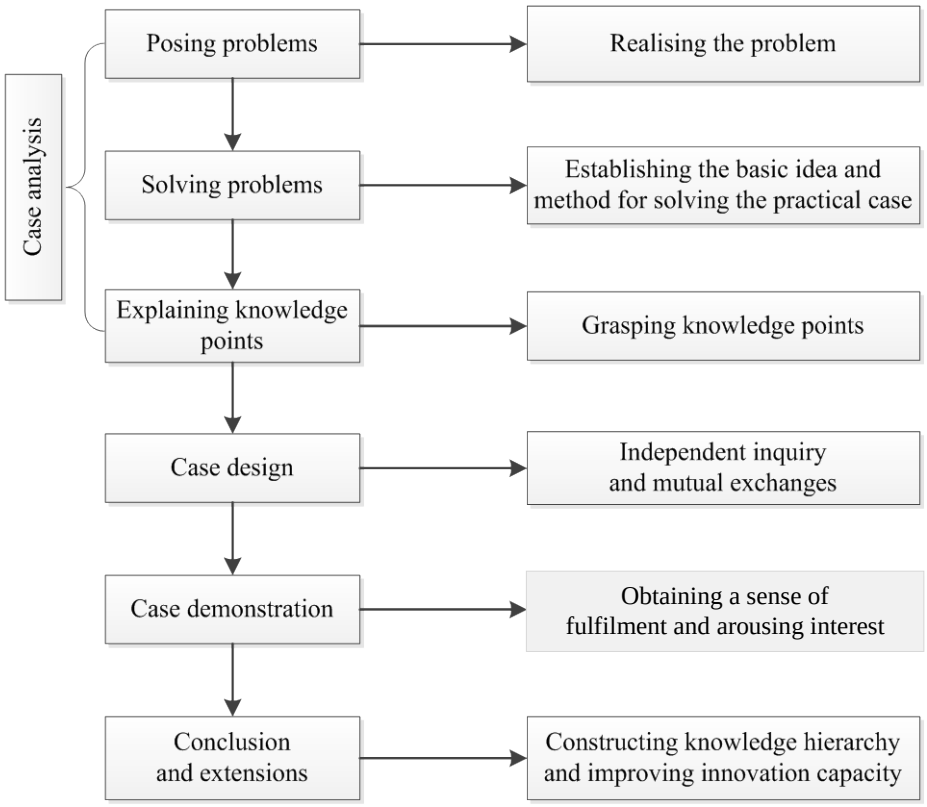

Figure 1: Implementation process of case teaching.

COURSE CASE BASE

Case teaching requires building a case base, i.e. a relevant set of cases. A course case base should include diverse content, include many real cases, and offer sufficient resources for self-study and practice. As extra-curricular knowledge for students, the cases are an important means of improving graduate students' teaching and achieving teaching goals. The Artificial Neural Networks and Applications course is an important specialty degree graduate course in control science and engineering, which combines control science and engineering. By cultivating innovation and creativity, the typical case base improves the practical abilities of students.

The authors have accumulated several teaching cases in recent years. The selected course cases mostly come from the authors' research work or typical cases in China and abroad. Specific content is shown in Table 1.

Table 1: Case base.

Module	Knowledge	Case
Introduction	What is a neural network controller?	Three cases of neural network control structure
Basic principles of neural networks	Biological neuron and artificial neuron model; Perceptron; Linear neural network; Multi-layer feed-forward neural network and BP algorithm; Radial basis function neural network; Cerebellar model neural network; PID neural network; Locally recurrent neural network; Continuous Hopfield network	The realisation of the Hebb learning rule
		Neural network design using Simulink and GUI
System identification based on neural networks	System identification theory based on neural networks; Linear dynamic system model and identification; Nonlinear dynamic system model and identification; Inverse model of the linear dynamic system and identification; Inverse model of the nonlinear dynamic system and identification; Inverse model of the nonlinear system; Inverse model identification of the neural system; Inverse model identification of the nonlinear system; Inverse model identification of the neural network	The hysteresis nonlinearity modelling of the magnetically controlled shape memory alloy actuator based on the BP algorithm [1]
		The research of the neural network inverse model for the hysteresis nonlinearity modelling of the magnetically controlled shape memory alloy actuator [11]
		Steering gear control based on neural network inverse model identification [12]
Neural network control	Design and implementation of the neural network control system; The PID control based on the continuous Hopfield network; Neural-network-based self-tuning control; Neural PID control; Neural internal model control; PID neural network control; Reinforcement learning and neural control	Single Neuron PID control method for hysteresis nonlinearity of the piezoelectric servo valve [13]
		The research of the PID neural network control method for the hysteresis nonlinearity of the magnetically controlled shape memory alloy actuator [14]
		The fuzzy neural network control based on reinforcement learning of the magnetically controlled shape memory alloy actuator [15]
Genetic algorithm and neural control	Basic genetic algorithm; Genetic algorithms and function optimisation; Genetic algorithms and system identification; Genetic algorithms and PID control	The programming and implementation of Matlab and C++ programming based on basic genetic algorithms
		Identification of the hysteresis nonlinearity based on the genetic algorithm
		Control system design of double nozzle flapper piezoelectric valve based on the genetic algorithm
		The PID control method with genetic algorithm for the hysteresis nonlinearity of a piezoelectric actuator

ANALYSIS OF THE TEACHING

To test the effect of case teaching, case teaching was contrasted with non-case teaching. Test subjects were graduate students of 2012 and 2013. Non-case teaching was used for 2012 students; case teaching was used for 2013 students. After study, the course assignments and results were analysed.

Figure 2 shows the marks for the module, *Basic Principles of Neural Networks*. It can be seen from Figure 2 that the average mark for 2012 students was 67%, while the average mark for 2013 students was 98%.

Figure 3 shows the results for the module, *System Identification based on Neural Networks*. It can be seen from Figure 3 that the average mark for 2012 students was 60%, while the average mark for 2013 students was 92%.

Figure 4 shows the results for the module, *Neural Network Control*. It can be seen from Figure 4 that the average mark for 2012 students was 63%, while the average mark for 2013 students was 88%.

Figure 5 shows the average marks for the module, *Genetic Algorithm and Neural Control*. It can be seen from Figure 5 that the average mark for 2012 students was 56%, while the average mark for 2013 students was 84%.

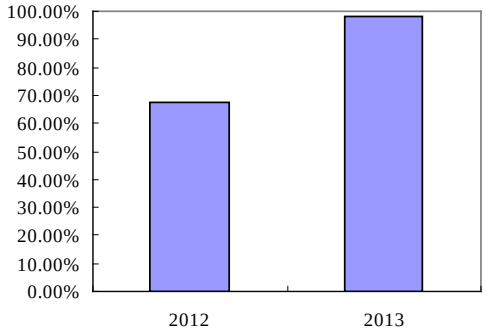

Figure 2: Results for the module, *Basic Principles of Neural Network*s.

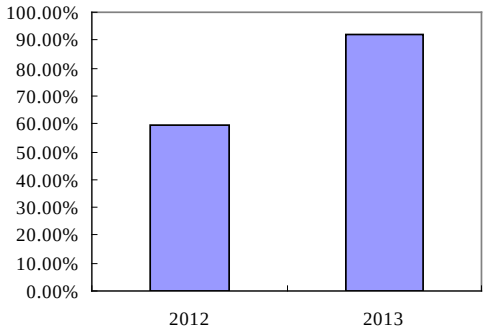

Figure 3: Results for the module, *System Identification based on Neural Network*s.

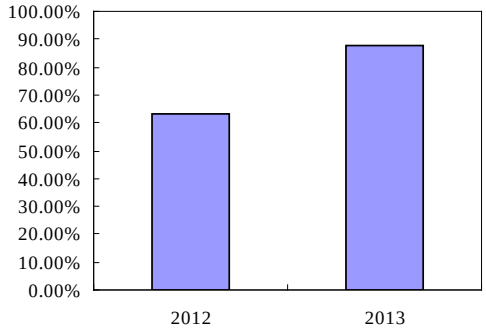

Figure 4: Results for the module, *Neural Network Control.*

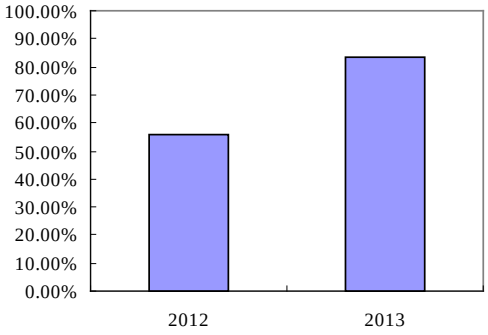

Figure 5: Results for the module, *Genetic Algorithms and Neural Control.*

Analysis of the results show that for the case-based content of the course, students are better organised in applying their knowledge to the analysis of cases, discussing problems and communicating. This can inspire students to learn by improving their ability to analyse and solve problems, and this in turn raises the quality of classroom teaching and enriches the teaching experience of teachers.

CONCLUSIONS

Artificial Neural Networks and Applications is a deeply theoretical postgraduate course, which needs to be practical so that students can properly understand neural network control. Traditional teaching methods do not normally produce

good results. The use of case teaching as a way to teach the course was reported in this article. Case teaching is a new teaching model, which stimulates students' interest in learning.

Case-teaching method can compensate for the weaknesses of the traditional teaching and help to improve students' practical and innovative abilities. In case teaching, there are more opportunities for students to learn and apply knowledge in practice and this inspires students' interest in solving practical problems. It mobilises the enthusiasm and initiative of students for independent study and, hence, students acquire knowledge and improve their problem-solving ability.

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