Teaching Reform Exploration of "Digital Signal Processing" Driven by Engineering Project

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Abstract. A new teaching method is proposed for "Digital signal processing" course for postgraduate students because it is very theoretical and abstract. Digital signal processing teaching reforms consist of the basic theory integration and experiment simulations. The teaching process is driven by engineering project and combined with digital signal processing flow. The classic contents of digital signal processing are deeply analyzed combined with simulations. Algorithms commonly used in engineering are treated as the contents of experiment simulations and complete engineering simulation designs are treated as practice topics. Through this reform practice, postgraduate students will greatly improve in independent study, practice and collaboration and will lay the foundation of their future research work.

Introduction

Digital signal processing course is an important degree graduate class in electronics, control and information field. Its basic theory, basic method and basic implementation method are widely applied in many related areas and it lay a solid foundation for the students who will engage in theoretical research, application development and technical management in the future [1-3]. This course is a very strongly theoretical course involving a very wide range of knowledge. However, graduate students’ source is complex, their basis and knowledge structure is different and the student's requirements on the digital signal processing course are also diversified [4-6].

Aiming at the above characteristics a new teaching method is put forward to which is engineering project-driven combined with digital signal processing. According to digital signal processing teaching reforms integrate the basic theory and deeply analyze the classic contents of digital signal processing with the method combined theory with simulation. Algorithms commonly used in engineering are treated as the contents of experiment simulations and complete engineering simulation design are treated as practice topics.

This paper integrates curriculum content according to the digital signal processing. Then the project-driven teaching reform of engineering examples are given and the analysis are carried on according to the digital signal acquisition, analysis and processing process. Design simulation experiments are designed comparing with the relevant course content and some simulation results are get. Finally, the above content is summarized.

Integration of basic theory

In order to enable students to master the basic knowledge and skills of the courses in the shortest period of time, it is particularly important to select the content of teaching and straighten out the curriculum system [7]. Under the guidance of this principle, we have integrated a variety of digital signal processing materials, discarded the dross and selected the essence, and the organic integration of curriculum content was obtained, summing up a number of knowledge points. According to the sequence of obtaining, analyzing and processing of digital signals, the purpose of keeping pace with time is attained combined with the introduction of frontier knowledge in the process of teaching. The structure of the whole theoretical knowledge is shown in Figure 1.
In the implementation of the teaching process, the careful organization of basic theoretical knowledge is focused to be explained. We reduce some tedious theoretical derivation, pay great attention to the corresponding relationship between mathematical and physical properties of the theory, and emphasize relevance of knowledge and the physical meaning and application of conclusion. Then the simulation instruction is carried out with the corresponding engineering examples. As for the introduction of the frontier knowledge, the comparison method is used to explain their difference with basic theory and their engineering application. This framework not only meets the needs of poor students, but also makes better students to be developed.

**Teaching Reform Driven by Engineering Projects**

We choose proper engineering projects related with the digital signal processing. In accordance with the digital signal acquisition, analysis processes and processing throughout the entire course and based on the simulation experiment in the theoretical knowledge corresponding to the actual project, we help students understand the signal processing and deepen their understanding of the basic theoretical knowledge.

**Project Example**

In the teaching process we used to capture the field of direct sequence spread spectrum communications signal as an engineering example, the correspondence between the core and the theory used in the signal processing as shown in Figure 2. By a corresponding diagram between signal processing and theory, students can get a simple and intuitive cognition of course content applied in the engineering project. We materialize the abstract to make students understand and accept the course content.

![Signal Processing Flow Chart](image_url)
**Design of Simulation Experience**

The simulation experiment is an important part of cultivating graduate students’ application ability and the experimental design is mainly relying on the engineering project throughout the entire course. As shown in Figure 2, Signal processing involves the sampling theory, FIR low-pass filter, variable sampling rate of the signal processing and FFT implementation. According to the signal processing flow, four MATLAB simulation experiments were designed in accordance with the process "how to acquire digital signal, how to analyze the characteristics, how to filter out the noise, and how to estimate the spectrum": (1) signal Interpolation and decimation; (2) correlation, convolution and its implementation in frequency domain; (3) design and implementation of FIR filter; (4) comparison of different power spectrum estimation. These content and the basic theory of knowledge have close relationship, so that students learn to use simulation software, grasp the theoretical knowledge profoundly, and understand how the theory and engineering practice is combined at the same time.

Taking the experiment 1 as an example, it is necessary for students to understand why to change the sampling rate of the signal, and to master how to change. The following 2.1 sections of the project is an example to carry out a simple note. In the frequency domain, the FFT of the input data and the pseudo code sequence and the IFFT of their conjugate product are needed to be calculated. If the 2-FFT algorithm is used, the input data length is 2. In pseudo code spread spectrum ranging system, the ratio of the signal sampling frequency and the rate of PN code can’t be used to accurately represent the value of the error, which is not close to the value of the integer. In this way, the correlation time of the sampling points often do not meet the requirements of the 2-FFT. In order to achieve this, it is needed to add a data preprocessing unit based on interpolation and extraction to change the input sampling data processing to meet the input to the FFT computing unit of the data 2 of the power of the integer. This is the simulation content of experiment 1.

Explain why want to do it, and then is about how to do. First of all, let the students check the information, find the appropriate interpolation method to collect, and combine the course of continuous time signal sampling and reconstruction of this part of the content to explain, and then compare the simulation. In this way, the simulation results of different processing methods can be compared, and the advantages and disadvantages of various methods are summarized. At the same time, the theoretical knowledge is verified by comparing with the theoretical knowledge. The classic two methods are (a) Sinc interpolation method and (b) linear interpolation method, and the corresponding simulation results are shown in figure 3, from which it is can be seen that the simulation results are not significantly different, at this time we need to compare the difficulty of the two algorithms, the calculation size and other aspects of the comparison, select the appropriate algorithm, here to choose a linear interpolation.
Comprehensive Practice

With the completion of the course content and simulation aspects, most of the project-involved simulations throughout the entire course have been completed. Then the students gather all the contents in series to achieve a complete engineering simulation and stress the whole idea of digital signal acquisition, analysis and processing. Based on the actual demands, all students are divided into several small groups in terms of their research fields or interests. Each group is formed by two or three students. They cooperate with each other and carry out experimental research and exploration by writing simulation code, demonstrating simulation results and writing experiment reports, which can effectively improve their abilities of engineering practice and thesis writing.

Summary

For postgraduate students, "digital signal processing" course is very theoretical and abstract. A new teaching method is put forward in which teaching process is driven by engineering project. We integrate the course content according to digital signal processing flow. Aiming at specific project cases, we design simulations throughout the whole course, and design comprehensive practical projects to enhance the students’ abilities. We hope that students not only master the basic theory of digital signal processing, but also improve their abilities of self-learning, engineering practice, scientific innovation, thesis writing and team collaboration, etc. Since this reform is just under way, it needs to be gradually improved during teaching procedure. We plan to use MOOC method in the following reform, which requires students to preview the contents in their spare time and think about questions in the course. So their abilities of self-learning and innovation can be improved.

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