Digital Signal Processing

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Abstract

These are notes on **DSP**.

Contents

1 Introduction

1.1 Overview

Some prerequisite:

In order to study this course better, you need to have some mathmatical maturity and a foundation of calculus.

The textbook we use is Discrete-Time Signal Processing, 3rd edition written by A. V. Oppenheim.

1.2 Some Suggestions

In the first subsection, let's give the following suggestions.

No reading, No learning.

After we enter a high level of learning, we mainly depend on reading, because no one will tell us the key points. The reason for setting up a series of courses is to make our learning more targeted.

No writing, No reading.

What is effective reading? You must write something in the paper, such as the math notations. Only in that way will you brain not skip many details.

No data, No truth.

In the vast majority of scientific fields, we must apply theroies and methods to real data rather than relying on simulation.

No Analytic, No understanding.

If you say, "You have well understood something", you must provide a detailed analysis using symbolic language.

No programming, No coginition.

Finally, if you wish to have an intutive coginition of something, the typical approach is to use a series of visualization methods (such as pictures, tables...) to present the images in your mind.

1.3 Digital vs Analog

There are the following differences between the two.

First, digital means programmable. Analog rely on hardware, digital are true software, which is very flexible and easy to change.

Second, in the digital world we use bit to describe precision. And digital has a high and controllable precision.

Third, storing, digital has a high storage density and compressible.

Finally, digital's cost is low, because it's manufactured on a silicon wafer.

1.4 Course Arrangement

The digital signal processing course has the following chapters.

Chapter1: Preliminary for Digital.

In this chapter, we will introduce Discrete Signal and System from the following two perspectives:

- Time domain;
- Frequency domain.

Chapter2: How to obtain digital signal.

In this chapter, we will introduce:

- A/D: Using sampling to help us move from the real word (continuous) to digital word.
- D/A: Return journey.

Chapter3: How to process digital signal.

In this chapter, we have two basic tools for recoginzing signals:

- Fourier Transform.
- Z transform.

Also we will introduce Linear Filtering;

- Representation: Discrete Convolution.
- Implemention: Time domain $\longleftrightarrow$ Frequency domain.
- Architecture: from software $\longrightarrow$ chip.

Chapter4: How to improve performance.

We have the following pursuit:

- Faster: FFT.
- More accurate
  - Quantization Noise.
  - Finite word length.

Chapter5: How to design linear filters.

We will introduce the following classic filters:

- FIR.
- IIR.
- Hilbert transform.

Chapter6: How to extend linear filters.

We will introduce:

- Real signal $\longrightarrow$ Complex signal.
- Multirate filters.

Chapter7: How to apply linear filters.

1.5 History of DSP

Now let's briefly review the history of DSP.

1730, Fourier, Fourier Transform.

In the process of studying the heat conduction, Fourier discovered that:

$$\text{any complex motion} \longleftrightarrow \text{linear combination of simple harmonic motion}$$

and that is the Fourier Transform.

1900, Marconi, Electromagnetic waves are simple harmonics

This discovery extends Fourier Transform form thermal to electromagnetic.

1930, Bode, Control Science.

In the field of control science, the first step is perception. Perception is sampling to get data, and extract useful information from the data.

1940, Word War 2.

During this period, two important discoveries were made:

- Wiener Filtering: the foundation of Optimal Filtering (Stochastic Process required).
- Nyquist-Shannon Sampling Theorem.

1950, The Apollo Moon-Landing Project.

This plan gave rise to Kalman Filtering, another methods of Optimal Filtering.

1960, Cooley and Tukey, FFT.

This is the origin of signal processing.

1980, DSP (processor).

A special CPU designed for signal processing task.

2 Lecture2