

多媒体 通信技术基础

The Basic Principles of Multimedia
Communications

■ 沈晋原 编著



國防工業出版社

National Defense Industry Press

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Jinyuan Shen

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前 言

在国内理工科本科生、研究生教材及参考书中,目前还没有一本现成的与多媒体通信专业相关的中英文双语教材/参考书可用,很多开设双语课程的高等院校只能使用英文原版或原版引进版权参考书作为相关课程的教材。这里存在着如下几个问题:

1. 英文原版或原版引进版权参考书价格都相对较高,尤其是英文原版技术书籍,每本书大约要 200 美元左右,这是国内高等院校学生无法承受的。即使是原版引进版权参考书,其价格也要在 100 元人民币以上,这对国内高等院校学生,尤其是本科生无疑也是一个负担。

2. 原版引进版权参考书虽然相对于英文原版参考书价格低了很多,虽然是个负担,但学生仍可勉强接受。由于原版引进版权参考书数量和品种极为有限,所以内容上很难恰好符合所开课程的要求。

3. 国内学生由于受语言环境限制,尤其是本科生的英文水平仍然普遍有限,阅读英文原版专业书籍在速度上和理解上都存在很大困难。这使教师和学生双方对课程的理解和完成都产生了困难。

出于同样上述原因,在理工科专业领域执教、工作的专业技术人员及学习深造的研究生、学者也面临着上述同样的问题。尤其随着我国对外开放日益深入,国内外学术、专业交流日益频繁,更需要专业人员、学者能够尽多尽快掌握和了解中英文在自己专业领域中描述的不同,以便更好、更方便地与国外同行交流。

出于上述考虑,本书将是第一本这方面的中英文双语专业课教材或参考书。希望能够成为国内本科生同名课程的一本实用教材和国内研究生、同行们的一本必不可少的、方便、实用的参考书。

如上所述,本书的目的之一是让同领域内的专业技术人员、学生、学者,手持一书就可以了解中、英文电气、电子工程领域中同一概念、理念的不同说法,所以本书不着重于词对词,句对句的中英文翻译,而是着重于电子工程领域中同一概念、理念中英文的不同说法。换句话说,读者理解了书中同一概念、理念的中文解释后,可以直接用书中相应段落的英文解释和国外同行交流,而用不着再去翻查字典等辅助工具书籍。这是本书的特点之一。

另外,由于本书上述的有意识的特殊写法,使得本书的中英文部分可以相对独立地各成一体。这使得它不仅成为多媒体通信技术这一电气、电子工程领域中通信、信息及其他专业本科生高年级的专业课中英文双语课教材,也可以作为还没有能力和条件开此双语课课程的中文单语课教材。但不同于其他单语课教材的是,她含有了相应的英文讲解部分,这使得它可以成为一本从单纯中文课到中英文双语课过渡的一本很有价值的教材,这是本书的另一大特点。

全书共分 6 章,第一章介绍了多媒体技术的发展简史,引进了多媒体通信技术中所用的

数据压缩、有损和无损编码、信息熵等重要概念；第二章进一步论述了多媒体及其多媒体通信技术的一些基本概念，包括它们的基本特性、应用领域及关键技术；第三章阐述了多媒体通信技术基础理论——数据编码的基本概念及理论，进一步较为详细地介绍了几种常用的重要的无损编码算法；第四章介绍了多媒体通信技术基础理论之一的音频压缩编码的基本理论和方法，包括声音数字化及 PCM 等重要概念和方法；第五章阐述了多媒体通信技术基础理论的重要组成部分，静止图像压缩的基本理论和重要方法，详细介绍了二值图像压缩编码和 JPEG 压缩编码方法；第六章阐述了多媒体通信技术基本理论的另一重要组成部分，视频压缩编码的基本理论和重要方法，引进了运动估计、运动补偿等重要概念，详细介绍了 MPEG 系列压缩标准及压缩算法，同时也介绍了相应的 H.264 系列算法。

在编写过程中，参考了中外大量多媒体、多媒体通信技术方面的相关书籍和电子资料，在此向这些书籍的作者和相关网站表示衷心的感谢。

最后，尽管本人在这个技术领域在国内外学习、工作多年，比较了解国内外工作市场、同行的基本要求，但毕竟个人能力有限，不足之处一定难免，欢迎各位前辈、同行批评指正。同时希望本书能够起到一个抛砖引玉的作用，能引出更多更好地双语专业教科书和参考书问世。

沈晋原

2014 年 12 月

Preface

Currently it is still very hard to find a suitable dual language textbook or technical reference book in science and technology area in mainland China. The universities/colleges which have the dual language courses have to use either the original technical books from abroad or the ones China bought the copyrights and republished in China as the textbooks. There are several issues existing under this circumstance:

1. Both original technical books from abroad and the ones China bought the copyrights and republished in China are too expensive to the Chinese undergraduate, graduate students, and professionals, especially the original ones which cost around USD\$200. Even the republished ones still roughly cost more than RMB ¥ 100 which is still a burden to the students and professionals in China.

2. In addition to the cost, the types and options of the republished technical books are very limited that makes it hard to match the reference book's contents to the course's requirements.

3. Under the current circumstances, the Chinese students, especially the undergraduate students' English abilities are still limited. This makes it hard for them to study the original English technical books. General speaking, for most of them, their reading speed and understanding are still

not that good yet. This makes it hard for both the teachers and the students to complete the course.

Same other issues exist among the university teachers, professionals, scholars, and graduate students. Communications between the Chinese scholars and professionals and the foreign scholars and professionals are getting more and more often and deeper along with the Chinese door opening. Chinese scholars, professionals, and students need quickly to know more about the differences between English and Chinese to describe the same technical ideas in the same areas to efficiently communicate with the foreign professionals who are working in the same professional areas.

This book, will be the first Chinese and English dual language professional textbook/reference book in China. Hope it will be a practical textbook for the university grade four undergraduate students' Multimedia Communication Technology course and very useful reference book for Chinese professionals of these technical areas.

As stated above, one of the major reasons to write this book is to provide the Chinese professionals working in the same technical area a good reference book. With this one book, those professionals would be able to know the different descriptions between English and Chinese in Electrical Engineering areas. After knowing those English descriptions, they can directly use them to communicate with the foreign professionals without checking a technical English-Chinese dictionary again as usual. For this reason, instead of like an English-Chinese dictionary translating the technical words or sentence one by one, the book emphasizing the different descriptions of English and Chinese for the same technical ideas. This is one of the advantages to choose this book.

Such a way the book is written, makes its Chinese language part is independent from its English language part. In another word, besides to be served as a dual language teaching textbook and technical reference book, the book could be used as a pure Chinese textbook as well just ignore the English part. This gives the universities without dual language course a good option to use the book as a transfer book from pure Chinese teaching to dual language teaching. In this case, the biggest advantage compared to using a pure Chinese language textbook is that this book gives a good English explanation to the same technical ideas that provides a very good reference for the teachers and the students. For the same reason, the book is a very good reference book for the professionals working in this electrical engineering areas.

The whole book is organized in 6 chapters. Chapter 1 begins with the simple developing history of the multimedia technologies and then discusses some important ideas used in multimedia communication technologies, such as data compression, lossy and lossless coding, and information entropy. Chapter 2 covers the basic ideas of multimedia and multimedia communication technologies including their basic characteristics, application areas, and key technologies. Chapter 3 is devoted to basic principles of multimedia communication technologies, the basic idea and theory of data coding. Furthermore, covers several most often used lossless coding algorithms in detail. Chapter 4 provides a detailed overview of audio compression coding basic theory and methods, one of the basic principles of multimedia communication technologies. This includes audio signal digitalization and PCM etc important ideas and algorithms. Chapter 5 concentrates on the still image compression basic theory and core algorithms, which is a major part of the

multimedia communication technology base principles and methods. It further talks about the bi-level image compressing coding and JPEG compression coding in detail. Chapter 6 is devoted to the video compression coding basic theory and core algorithms, which is another major part of the multimedia communication technology base principles and methods. It introduces the motion estimation, motion compensation, and etc important ideas and gives out the detailed MPEG series compression standards and algorithms. Meanwhile, it introduces the correspondent H.264 series algorithms.

During the writing process, I referred quite a bit local and foreign multimedia and multimedia communication technology technical books and professional articles. Here, I would like to say thanks to those books' authors and those webpages.

Finally, I have been studying and working in this technically area for years locally and abroad, understand the job market requirements and colleagues' basic desire. Even this, my personal ability is still limited. I have tried hard. But there must be still some errors in the book. Any suggestions and advices from either former professionals or colleagues are welcome. At the same time, I hope the book could be worked as an introduction for other better ones. After this one, could see more and better dual language technical textbook/reference books are published.

Jinyuan Shen

December, 2014

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第一章 多媒体发展简史

1.1 数据压缩技术半个世纪发展概述

1.1.1 数据压缩及其重要性

首先，来看一下什么是数据压缩，数据压缩为什么重要。

数据压缩有两大功用。

第一，可以节省存储空间。

第二，可以减少对带宽的占用。例如，数据压缩技术的快速发展使在手机上观看高清视频成为现实。

简单地说，如果没有数据压缩技术，就没法用 WinRAR 为 Email 中的附件瘦身；如果没有数据压缩技术，市场上的数码录音笔就只能记录不到 20min 的语音；如果没有数据压缩技术，从 Internet 上下载一部电影也许要花半年的时间……可是这一切究竟是如何实现的呢？数据压缩技术又是怎样从无到有发展起来的呢？

数据压缩的发展史可以形象的归纳为如下一个环链：

由概率起源起始，到数学游戏的出现，从异族传说的流传，发展到现代的音画时尚，转而感到未来的展望。

当我们在 BBS 上用“7456”代表“气死我了”，或是用“B4”代表“Before”的时候，我们至少应该知道，这其实就是一种最简单的数据压缩。

Chapter 1 Multimedia Developing Brief History

1.1 Data compression technology development in the past half century

1.1.1 Data Compression and Its Important Role

First of all, what is data compression and why it's important.

Generally speaking, data compression does two major things.

One of them is to save the storage space.

The other one is to reduce the bandwidth usage. For example, years ago, it's like a dream for

us to watch movies by our call phones, the fast developing of the data compression technology has made our dreams become true.

Simply speaking, without data compression technology, we can't use the software, WinRAR to reduce the file size attached in our emails; without data compression technology, audio recording pen in the market may only can take less than 20 minutes recording; without data compression technology, it may take half a year to download a movie from the internet...Then how all off those happened? How the data compression technology progressed?

The data compression technology progressed like a ring as follows:

It started form the data probability, then a mathematical game appeared, followed is a legend, progressed to modern audio and videos, next goes to the future...

In China, people use “7456” to represent Chinese words: “Qi Si Wo Le” means “I” m very mad”. Both “7456” and “Qi Si Wo Le” have similar pronunciation. Almost all over the world, people use “B4” to represent “Before”. This is actually one of the simplest data compression.

1.1.2 数据压缩与信息论

严格意义上的数据压缩起源于人们对概率的认识。

当人们对文字信息进行编码时，如果为出现概率较高的字母赋予较短的编码，为出现概率较低的字母赋予较长的编码，总的编码长度就能缩短不少，这可谓是数据压缩的写照之一。

另一个典型的数据编码例子是著名的 Morse 电码（由美国的摩尔斯在 1844 年发明的，所以电码符号也称为摩尔斯电码——Morse code），电码 符号由两种基本信号和不同的间隔时间组成：短促的点信号 “.”，读 “的” (Di)；保持一定时间的长信号 “—”，读 “答” (Da)。

常用的 Morse 编码表列在表 1-1 中。

表 1-1 Morse 编码

Morse 电码	Morse 电码	Morse 电码	Morse 电码
A .-	K -. .	U .-. .	0 - - - -
B - . . .	L .-. . .	V .-. . -	1 . - - -
C - . . .	M - -	W .-. -	2 . - - -
D - . .	N - .	X - . - .	3 . - . -
E .	O - - -	Y - . - -	4 . - - . -
F .-. .	P .-. . .	Z - . . .	5
G - - .	Q - - . -		6 -
H	R .-. .		7 - - - . .
I . .	S . . .		8 - - - . .
J . - - -	T -		9 - - - . .

信息论之父克劳德·香农 (C.E.Shannon) 第一次用数学语言阐明了概率与信息冗余度的关系。在 1948 年发表的论文中，香农指出，任何信息都存在冗余，冗余大小与信息中每个符号（数字、字母或单词）的出现概率或者说不确定性有关。香农借鉴了热力学的概念，把信息中排除了冗余后的平均信息量称为“信息熵”，并给出了计算信息熵的数学表达式。

这篇伟大的论文后来被誉为信息论的开山之作，信息熵也奠定了所有数据压缩算法的理

论基础。从本质上讲，数据压缩的目的就是找出并消除信息中的冗余，而信息熵及相关的定理恰恰用数学手段精确地描述了信息冗余的程度。利用信息熵公式，人们可以计算出信息编码的极限，即在一定的概率模型下，无损压缩的编码长度不可能小于信息熵公式给出的结果。

1.1.2 Data Compression and Information Theory

Scientifically speaking, data compression actually started from the recognition of data probability.

When we encode the text, if we use shorter codes for the characters appeared more often in the text and longer codes for the characters appeared less often in the text, the total length of encoded codes will be reduced a lot. This is one of the advantages of data compression.

Morse code is another typical data encoding. It is invented by Morse, US in 1944. The code consists of two basic signals that separated by deferent intervals. The short dot signal “.” sounds “di” and the long dash signal sounds “da”.

The common used Morse codes are showing in Table 1-1.

Table 1-1 The Morse Code

Morse code	Morse code	Morse code	Morse code
A .-	K -.-	U ...-	0 ----
B -...	L -.-.	V ...-	1 .----
C -.-.	M --	W .--	2 ..----
D -..	N -.	X -.-.	3 ...--
E .	O ---	Y -.-.	4-
F	P	Z ---.	5
G --.	Q ---.		6 -....
H	R -.		7 -....
I ..	S ...		8 ----.
J .----	T -		9 ----.

The creator of information theory, C. E. Shannon first time provided the mathematical relationship between data probability and redundancy in 1948. Simply speaking, Shannon indicated in his thesis that any information has redundancy, the quantity of the redundancy depends on the uncertainties, probabilities of the characters, numeral digits, and words representing the information. Shannon used the similar concept, entropy that was introduced into thermodynamics in nineteenth century in the information theory. He defined the information entropy as the average information we need after taking out of the redundancy. He quantifiably defined the mathematical expression of entropy.

Shannon’s article was treated as the number one paper in information theory. Entropy becomes the foundation of almost all data compression algorithms. What do those data compression algorithms do is to reduce the redundancy involved in the given information. The entropy mathematical calculation formulas precisely describe how much redundancy existing in the given information. By applying the formulas, people know the encoding limits. In another words, under